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AN EVAPORATOR TYPE RADIOACTIVE LIQUID WASTE CONCENTRATOR WITH DISPOSABLE VESSEL

by

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Prepared for
U.S. Army Nuclear Defense Laboratory
Army Chemical Center, Maryland

March 5, 1963

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(A detailed design, equipment specifications, and cost estimate)

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CONTENTS

1. SUMMARY

This report presents the detailed design specifications and operating instructions for a prototype evaporation unit with disposable vessel for concentrating radioactive liquid wastes. The design is based on the use of drums as evaporation vessels so adapted that the feed inlet, vapor outlet, steam connections, and liquid level control are detachable permitting the drums to be detached from the rest of the equipment and shipped for land disposal.

The complete evaporation unit is portable, automatically controlled and has operating requirements for a supply of 80-150 psi steam for the evaporator, cooling water for the condenser, and electricity for operation of the pumps and controls.

Table 1 lists the general specifications of the unit.

Table 1

Specification of the Evaporation Unit

Evaporation rate (max.)	45 gal/hr.
Steam consumption (max.)	400 lbs/hr.
Steam pressure	100 psi
Cooling water (max.)	~25 gal/min.
Operating pressure (max.)	5 psi
Operating temperature (in evaporator)	212-290°F
Evaporation cycle (replacement of drums)	3-13 weeks
Final concentration of residue	500-1000 g/liter
Materials of construction:	
Evaporation drums	Carbon steel
Steam lines	Carbon steel
All others	Stainless steel
Overall size:	
Length	10 feet
Width	7 feet
Height	11.5 feet
Approximate weight (empty)	6000 lbs.

A complete list of equipment for the prototype test unit, excluding pipes and fittings, is presented in Table 2. Detailed specifications for each piece of equipment are given in Section 8.

Table 2

Complete List of Equipment for Prototype Test Unit

(All prices are F.O.B.)

No.	Quantity	Unit	Price per Unit	Total Price
E-1	2	Evaporator drum, carbon steel	$ 435.00	$ 870.00
E-2	1	Drum jacket, steam heated	185.45	185.45
E-3	1	Entrained liquid separator	357.00	357.00
E-4	1	Condenser and subcooler	820.00	820.00
E-5	1	Intermediate condensate tank	250.00	250.00
E-6	2	Activated carbon cartridge	115.00	230.00
E-7	2	Ion exchanger cartridge	115.00	230.00
E-8	1	Feed tank	500.00	500.00
E-9	1	Condensate tank	500.00	500.00
E-10	1	Central control panel	75.00	75.00
E-11	1	Steel frame	600.00	600.00
E-12	1	Evaporator cart	151.20	151.20
I-1	3	Temperature indicator	10.35	31.05
I-2	3	Temperature indicator	10.35	31.05
I-3	1	Temperature indicator	72.75	72.75
I-4	1	Temperature indicator	94.00	94.00
I-5	1	Temperature indicator and alarm	126.00	126.00

Table 2 (continued)

I-6	1	Pressure indicator and alarm	75.80	75.80
I-7	1	Liquid level controller	200.50	200.50
I-8	1	Liquid level controller	146.50	146.50
I-9	1	Liquid level controller	205.50	205.50
I-10	1	Steam rotameter	156.00	156.00
I-11	1	Feed rotameter	96.00	96.00
I-12	1	Cumulative flow meter	281.72	281.72
I-13	1	Condensate sight flow indicator	99.90	99.90
I-14	1	Steam pressure regulator	90.00	90.00
I-15	1	Steam pressure indicator	12.50	12.50
I-16	1	Conductivity indicator	114.50	114.50
I-17	1	pH recorder	345.00	345.00
I-18	2	Liquid level gauge	119.00	238.00
P-1	1	Centrifugal pump	445.00	445.00
P-2	1	Centrifugal pump	445.00	445.00
SVF-1	1	Steam solenoid valve	153.00	153.00
SVF-2	1	Feed solenoid valve	105.00	105.00
SVF-3	2	Steam traps	45.50	91.00
SVF-4	2	Feed filters	30.65	61.30
SVF-5	6	Flexible piping		200.19
SVF-6	1	Feed pressure relief valve	132.20	132.20
SVF-7	1	Pressure relief valve	132.20	132.20
VF-1	24	3/4" Stainless steel globe valve	48.75	1,170.80
VF-2	1	3/4" Stainless steel needle valve	32.70	32.70

Table 2 (continued)

VF-3	2	3/4" Stainless steel check valve	33.80	67.60
VF-4	2	1" Stainless steel globe valve	57.20	114.40
VF-5	2	1" Iron globe valve	17.94	35.88
VF-6	3	1½" Iron globe valve	28.73	86.19
VF-7	1	1½" Iron needle valve	28.73	28.73
		TOTAL		$10,486.00

The estimated price of the assembled prototype test unit is $ 21,220.00. The estimated operating costs depend primarily on the cost of the evaporation drums and the concentration of solids in the feed. With the presently available price quotation of $165.00 per evaporation drum (in lots of 100) the operating costs are estimated at ~5 cents per gallon feed (including evaporation drums, labor, steam, overhead and maintenance, and exluding depreciation).

Due to its mobility, the unit may prove very useful and economical for atomic installations and laboratories where accumulation of liquid radioactive wastes is relatively small. In such places the high cost of shipping these wastes to central locations for concentration and disposal can be greatly reduced by the temporary periodic installation and use of this evaporation unit. Moreover, it is believed that the use of disposable evaporation drums will greatly reduce the hazards and labor involved in handling the concentrated radioactive residue.

2. DESCRIPTION OF UNIT

2.1 General Description

The evaporation unit (Figure 1) is based on the use of a disposable drum E-1 which serves as the evaporator. The drum is equipped with an internal steam-heated coil and an external steam-heated jacket E-2 . The feed solution (radioactive waste) is stored in the 300 gallon feed tank E-8 and is pumped through filter SVF-4 into the evaporation drum E-1 with pump P-1. The vapors from the drum pass through deentrainer E-3 and are condensed and subcooled in condenser E-4. The condensed vapors are collected in the intermediate drum E-5 and are pumped periodically (automatically controlled) with pump P-2 through the activated carbon cartridges E-6 and ion exchanger cartridges E-7 into the 300 gallon condensate tank E-9.

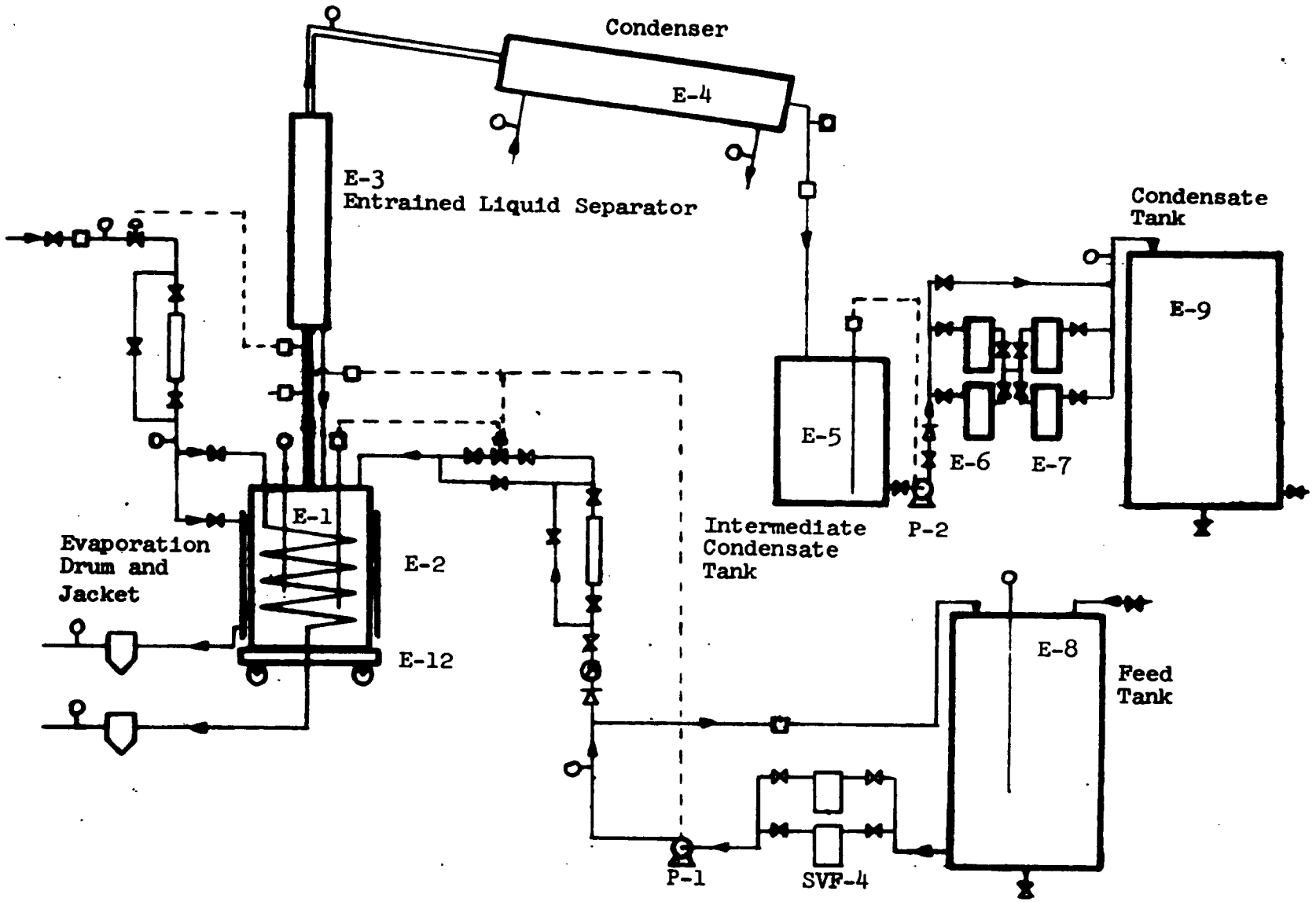
For operation, the evaporation drum E-1 is placed on the cart E-12, rolled into position and all the necessary connections made. All the connecting tubes are flexible. When the solution in the drum E-1 is concentrated, the drum is disconnected. The various openings are then plugged and the concentrated solution is ready for final disposal.

2.2 Evaporation Drum and Accessories (E-1, E-2, E-12)

The 55 gallon carbon steel evaporation drum E-1 is a specially designed vessel. For the prototype test unit, described in this report, this drum is equipped with a removable cover so that the inside of the drum may be inspected for corrosion and scale formation. For subsequent operation the

Figure 1

Flow.Diagram for Radioactive Waste Concentrator (Major Equipment Labelled)



drums may be equipped with permanently welded covers. For operation, an evaporation drum is placed on the cart E-12. The steam-heated jacket E-2, made from two parts, is placed around the drum. The evaporation drum is then rolled into position and the cart locked to the steel frame. All the necessary connections, i.e., feed pipe, steam and steam condensate pipes, vapor line, liquid level control and temperature indicator, are made. The connecting pipes SVF-5 are flexible and are equipped with unions. For details of connecting and disconnecting the evaporation drums see sections 6.1 and 6.5.

2.3 Activated Carbon, Ion Exchanger and Feed Filter Cartridges (E-6, E-7, SVF-4)

The activated carbon and ion exchanger cartridges are incorporated in the unit in order to remove trace amounts of organic and ionic materials from the condensed vapors.

The monobed activated carbon and ion exchanger cartridges, E-6 and E-7, are similar in structure. They are of a plastic construction with a clear sump (case) allowing visual inspection of the resin or activated carbon. Two cartridges of each type are installed in parallel thus enabling easy interchange without interrupting the operation of the unit. The two feed filters SVF-4 are installed in parallel for the same reason. These cartridge - type filters also have clear plastic removable sumps enabling visual inspection for accumulation of solids.

2.4 Feed, Condensate and Intermediate Condensate Tanks (E-8, E-9, E-5)

It is recommended that the unit be operated at neutral or slightly basic pH's in order to avoid excessive corrosion. The 300 gallon feed tank E-8 allows manual pH adjustment of close to one day's feed supply. The pH is adjusted by adding small amounts of concentrated NaOH or HCl through an opening in the cover of the tank. The pH is recorded (I-17) on the central control panel. Most of the particulate materials present in the feed tank will collect in the filters SVF-4. Heavier solid particles which may settle and accumulate occasionally in the feed tank can be removed by opening the valve located at the bottom of E-8. These solids may be agitated by circulating a small volume of water through feed pump P-1.

The 300-gallon condensate tank E-9 allows enough time for analysis of the condensate prior to discharge.

The intermediate condensate tank E-5 in combination with pump P-2 enables passage of condensate through the activated carbon and ion exchanger cartridges regardless of the relatively low elevations and high pressure drop.

2.5 Optional Equipment (OE-1, OE-2) (Not Shown on Figure 1)

The optional 2 kw electrical heater may be used overnight in order to keep the solution in the evaporation drum hot. This will shorten the start-up time in the morning. The magnesium electrodes OE-2 may be installed permanently in the evaporation drums to decrease corrosion.

3. INSTRUMENTS AND CONTROLS

The instruments incorporated in the unit (Figure 2) provide for automatic or manual operation. Automatic safety devices assure safe operation. The main indicators and controls are located on the central control panel. In addition, several auxiliary instruments, primarily temperature indicators, are provided in the prototype unit. These indicators will allow the calculation of heat balances during initial testing of this unit.

3.1 Central Control Panel (E-10)

All important indicators and controls, as well as the main electric switches and alarm system, are located on the central control panel. All instruments located on this panel are listed in Table 3.

Figure 2

Flow Diagram for Radioactive Waste Concentrator (Instrumentation Designated)

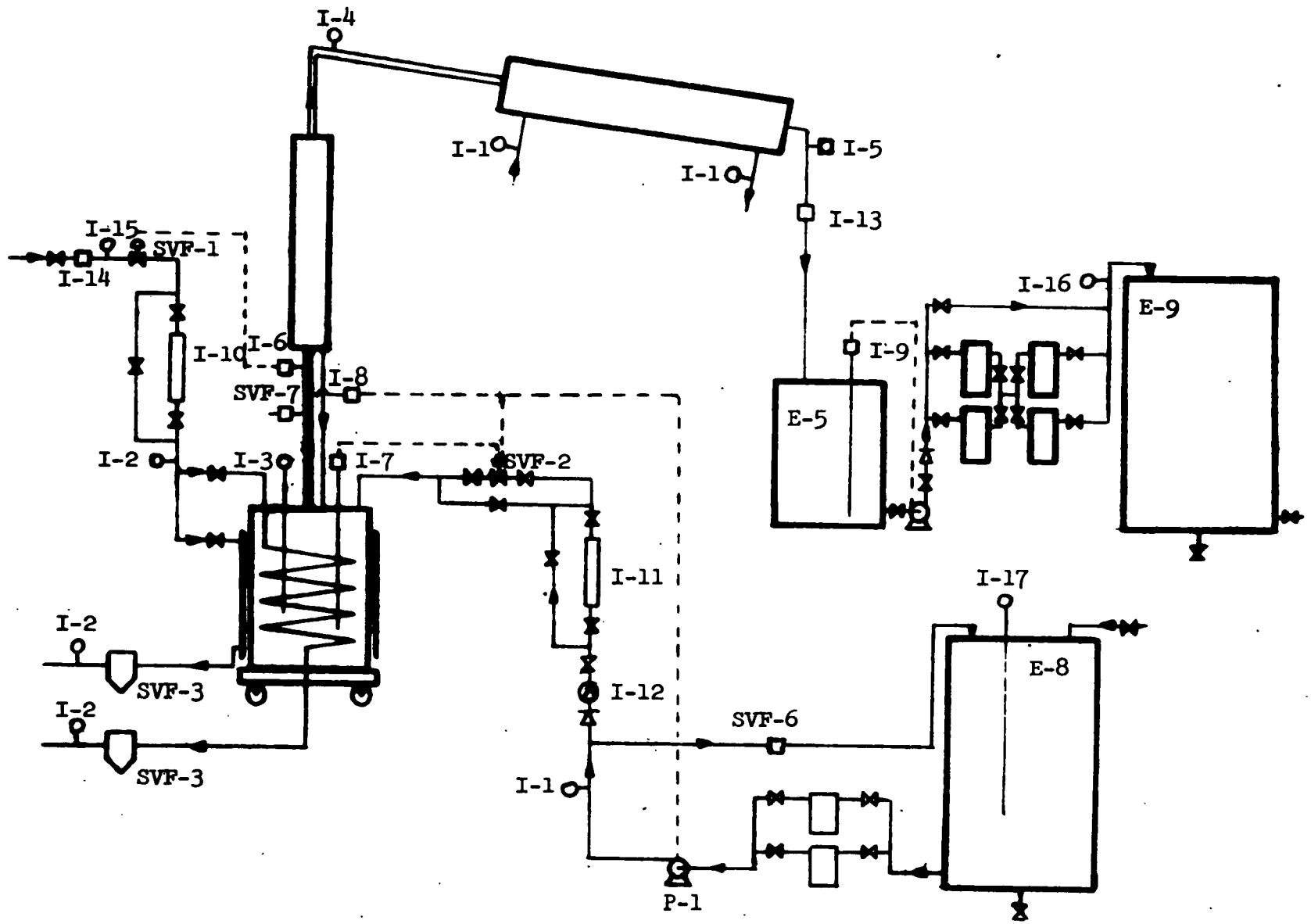


Table 3

Instruments and Controls on Central Control Panel

No.	Unit
I-4	Vapor temperature indicator
I-5	Condensate temperature indicator and alarm
I-6	Pressure indicator and alarm
I-7	Evaporation drum liquid level controller
I-8	Liquid level alarm
I-9	Intermediate condensate tank liquid level controller
I-10	Steam rotameter
I-11	Feed rotameter
I-12	Cumulative feed flow meter
I-16	Condensate conductivity indicator
I-17	pH recorder
Switch P-1	Feed pump switch
Switch P-2	Condensate pump switch
Switch OE-1	Optional 2 kw electrical heater
	Main switch
	Alarm bell

These instruments enable manual as well as automatic controls to be regulated from one central position.

3.2 Automatic Control

The automatic control system is of the "on-off" type. It consists of liquid level controls and solenoid valves.

Pump P-1 (Figure 2) pumps feed from feed tank E-8 into the evaporation drum. When the evaporation drum is empty, i.e. when a new evaporation cycle is started, the liquid level controller I-7 opens the solenoid valve SVF-2 and feed enters the drum. When the solution reaches the maximum operating level (approximately 10" from the top of the evaporation drum), the liquid level controller I-7 closes valve SVF-2. The resultant increase in the feed line pressure opens relief valve SVF-6 and pump P-1, which continues to operate, recycles the feed back into tank E-8. Steam is then admitted into the internal heating coil and external heating jacket of the evaporation drum. The steam flow rate is set manually using the steam rotameter I-10. The steam flow rate determines the rate of evaporation. The vapors, after condensing, are collected in the intermediate condensate drum E-5. When the drum is filled with condensate the liquid level controller I-9 starts the pump P-2, and the condensate is pumped through the activated carbon and ion exchanger cartridges into the condensate tank E-9. When the liquid level in the evaporation drum drops (to approximately 15" from the top) the liquid level controller I-7 opens valve SVF-2, the pressure in the feed line drops, relief valve SVF-6 closes and the feed flows into the evaporation drum until the proper level is reached.

Thus, automatic operation of this waste concentrator required only the manual selection of a steam flow rate which in turn determines the rate of evaporation.

3.3 Manual Control

For manual operation the feed flow rate is regulated with the needle valve positioned before the feed flow indicator I-11. By proper manipulation of this valve the feed flow rate can be kept constant and equal to the evaporation rate. The evaporation rate is regulated by manual adjustment of the steam flow rate. The emptying of the intermediate condensate tank E-5 is controlled automatically in all cases.

3.4 Safety Devices

A few automatic safety devices are incorporated in the unit.

Liquid level: If for any reason the liquid level in the evaporation drum rises into the 3" diameter vapor outlet line, the liquid level controller and alarm I-8 will close the solenoid valve SVF-2 and stop the operation of the feed pump P-1. In addition, the proper red light and the alarm bell located on the central control panel will be actuated.

High pressure: When the pressure in the evaporation drum reaches approximately 5 psig, the high pressure alarm I-6 will close the solenoid valve SVF-1 located on the steam line and operate the proper red light and alarm bell located on the central control panel. If the pressure continues to rise, the relief valve SVF-7 located on the 3" diameter vapor line will

be opened, relieving the pressure in the evaporation drum.

High temperature: When the temperature of the condensate is too high, the high temperature alarm I-15, operates the proper red light and alarm bell located on the central panel. This will indicate to the operator that the flow rate of cooling water to the condenser is too low.

3.5 Auxiliary Instruments

In addition to the instruments and controls required for the regular operation of the unit, 7 additional temperature indicators (I-1, I-2, I-3) are provided. These indicators, not located on the central control panel, will allow the calculation of heat balances during initial testing of the prototype unit.

4. ECONOMIC EVALUATION

4.1 Estimated Cost of Prototype Test Unit

The estimated cost of the prototype unit completely assembled and ready for tests is presented below.

Equipment	
Equipment (E and P)	$ 5,760.00
Instruments (I)	2,420.00
Valves (SVF and VF)	2,410.00
Pipes and fittings (estimated)	1,500.00
Insulation	150.00
Electrical	500.00
Shipping	400.00
Total	$ 13,140.00
Assembly and Installation	5,000.00
Total Direct Cost	$ 18,140.00
Contractors fee (7% of direct cost)	1,270.00
Contingency (10% of direct cost)	1,810.00
Total cost of installed unit	$ 21,220.00

4.2 Operating Expenses

The following assumptions were used in estimating operating expenses for the waste concentrator.

Cost of evaporation drums	$165.00
Volume of solution in evaporation drums	38 gallon
Final concentration of solution in drums	1000g/liter
Concentration factor (volume of feed per volume of residue)	500
Evaporation rate	300 gal/day
Operation (continuous)	8 hr/day
Operating days per year	260
Steam consumption	2800 lb/day
Price of steam	$0.50/1000 lb.
Labor	2 hr/day
Maintenance	$200/year

It should be noted that the cost listed for evaporation drums is based on the only price quotation available at the time of report preparation (quotation applies to lots of 100). In addition, it is assumed that an overhead of 100% of the direct labor will cover expenses such as electricity and other items normally included in overhead.

The estimated operating expenses per gallon of feed are summarized below:

Evaporation drum	0.87¢/gal
Steam	0.42¢/gal
Labor	1.67¢/gal
Overhead	1.67¢/gal
Maintenance	0.26¢/gal
Total operating expenses (excluding depreciation)	4.89¢/gal

Assuming that an evaporation unit will cost $16,000 and have an average life of 10 years, the depreciation cost will be 2.1¢/gal. (Note: These costs apply to a production model of the waste concentrator. The prototype unit will cost more).

In analyzing the operating expenses it should be noted that 4.89¢/gal applies only to operation of the unit according to all of the assumptions listed above and that actual operating costs can vary widely. They will be significantly affected, for instance, by the actual final cost of evaporation drums by the concentrations of solids in both the feed and residue, and by the reliability of automatic operation (which will determine the necessary direct labor - and, consequent overhead - costs.)

It is somewhat difficult to compare the operating expenses and total treatment costs (depreciation included) of the proposed unit with those of other radioactive waste concentrators due to differences in operating procedures,

accounting procedures and assumptions used.

During the early 1950's an informal cooperative program was carried out at five sites to compare the following types of evaporators (ANL-6233):

1. Forced-feed flash (Knolls Atomic Power).
2. Pot-type removable heating coils (Oak Ridge).
3. Vapor compression (Brookhaven).
4. Vertical tube circulation (Argonne National Lab.).
5. Double effect (Mound Lab.).

The concentration costs evaluated during this program varied somewhat, but generally were approximately 10¢/gal. A few more detailed cost evaluations, available for large evaporation units, are summarized below (NYO-7830):

Location	Waste Treated/Year (1,000 gal)	Operating Cost ¢/gal	Depreciation ¢/gal	Total Conc.Cost ¢/gal
Bettis Field	1,600	2.3	1.2	3.5
Brookhaven	367	3.3	13.7	17.0
Knolls	1,125	2.5	2.9	5.4

It should be noted, however, that these costs do not include any packaging costs. Based on these data, it may be concluded that the estimated operating cost for the proposed unit compared well with those for other installations.

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It should be noted, however, that these costs do not include any packaging costs. Based on these data, it may be concluded that the estimated operating cost for the proposed unit compared well with those for other installations.

5. CALCULATED EVALUATION OF CONCENTRATOR PERFORMANCE

The general calculated evaluation of performance presented in this section is divided into four parts:

1. Final residue concentration as a function of the amount (fraction) of water evaporated.

2. Concentration time and evaporation cycle.

3. Solution boiling point and required steam temperature.

4. Radioactivity level.

The general performance characteristics are important primarily for economic evaluation. It must be emphasized, however, that in handling radioactive solutions the simplicity and ease of operation which are believed to be part of this unit, are at least equally important even though it is difficult to assign a quantitative value to them.

5.1 Final Residue Concentration as a Function of Amount of Water Evaporated

The following material balance around the evaporation drum (Figure 3) applies to a complete cycle (terminated with 38 gallons of residue of concentration x_R).

$$Ft = Dt + R; \qquad R = (F-D)t$$

$$tF \cdot x_F = R \cdot x_R$$

$$(F-D)x_R = Fx_F$$

$$\frac{D}{F} = \frac{x_R - x_F}{x_R} = 1 - \frac{x_F}{x_R} = 1 - \frac{1}{\eta} \qquad (1)$$

where η is the concentration factor defined as x_R/x_F.

Equation 1 gives the fraction of feed volume to be evaporated, D/F, in order to get a residue concentration of x_R.

Figure 4 is a plot of residue concentration versus percent water evaporated. Figure 5 is, more generally, a plot of concentration factor versus percent water evaporated.

Both figures illustrate the highly non-linear relationship between amount of feed water evaporated and the residue concentration, as given algebraically by equation (1).

For example, evaporating 90% of a particular feed containing 5 g solids per liter over the period of a complete cycle will result in a residue containing 5% solids (50 g/liter). Increasing the fraction evaporated to 99%, i.e., 10% increase, will result in a residue containing 500 g solids per liter or a 10 fold increase in residue concentration.

5.2 Concentration Time and Evaporation Cycle

The concentration time, t_c, is defined as the time required to collect one gallon of residue of a given concentration. The concentration time depends on the concentration of solids in the feed, the final concentration of solutes in the residue and the feed flow rate.

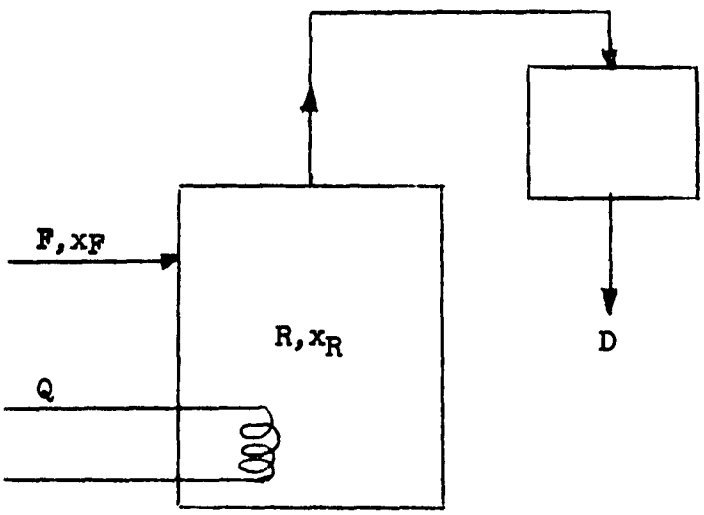
A material balance for the solutes contained in one gallon of residue yields:

$$t_c \cdot F \cdot x_F = (1)\ x_R \qquad (2)$$

$$t_c = \frac{1}{F} \cdot \frac{x_R}{x_F} = \frac{\eta}{F} \qquad (3)$$

Figure 3

General Schematic Diagram of the Evaporator



Nomenclature

F = feed flow rate, gallons/hour

x_F = feed concentration, g/liter

Q = heat input, B.t.u./hour

x_R = residue slurry concentration g/liter

D = condensate flow rate, gallons/hour

a = activity level, curies/unit volume

R = volume of liquid in the evaporator, gallons

t = total time of operation, hours

Figure 4

SOLIDS IN RESIDUE AS A FUNCTION OF THE PERCENT WATER EVAPORATED

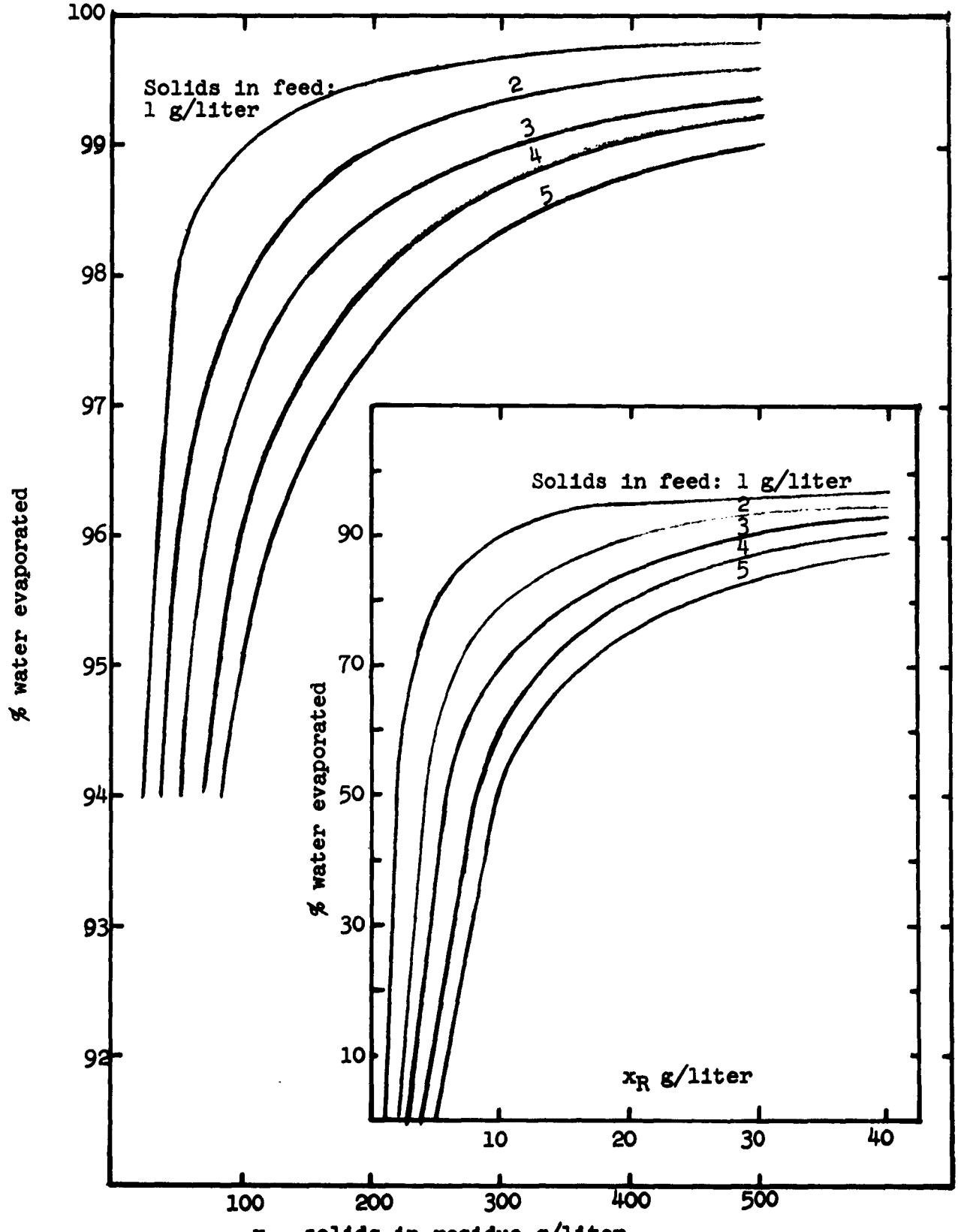


Figure 5

CONCENTRATION FACTOR AS A FUNCTION OF PERCENT WATER EVAPORATED

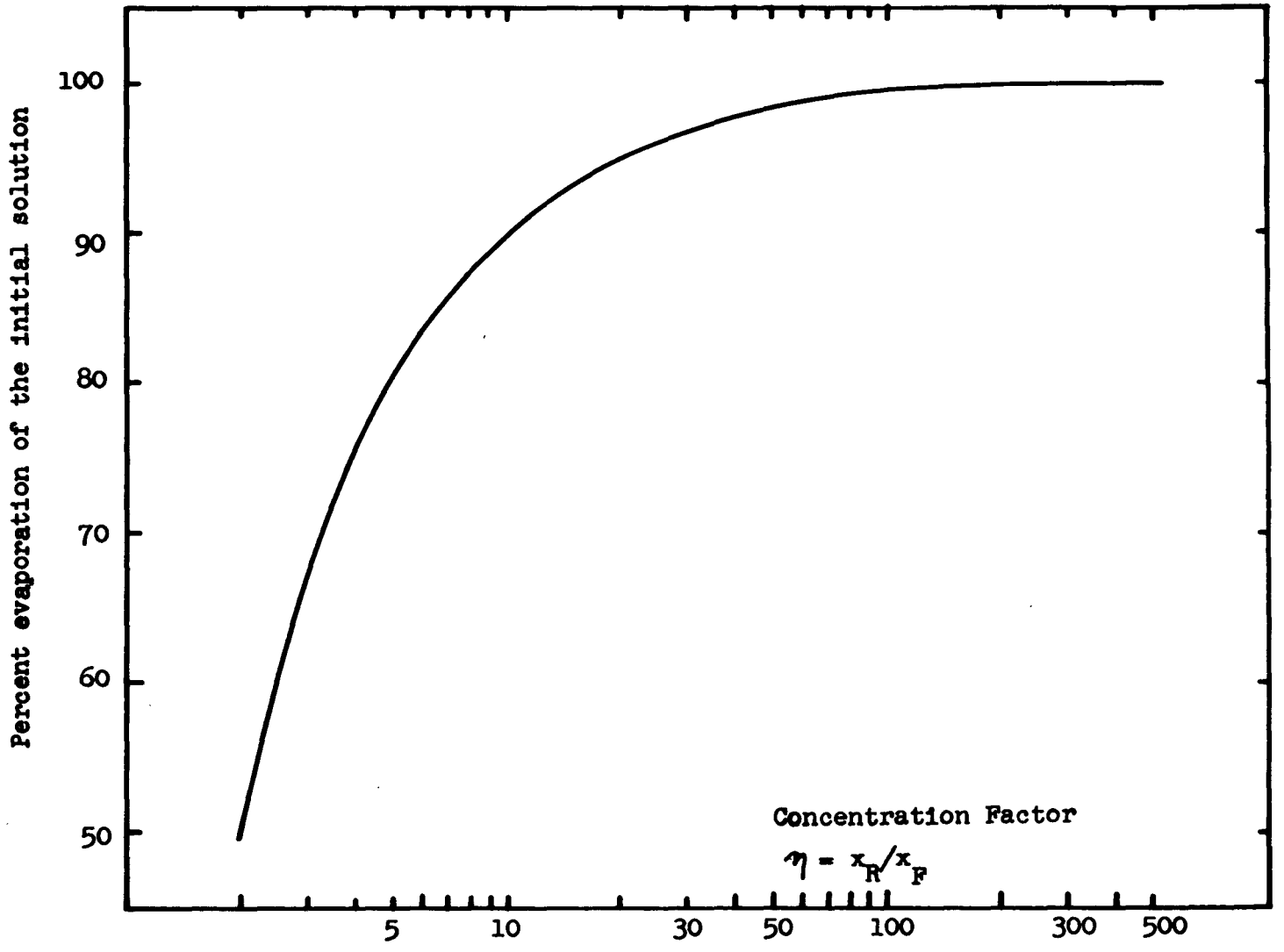
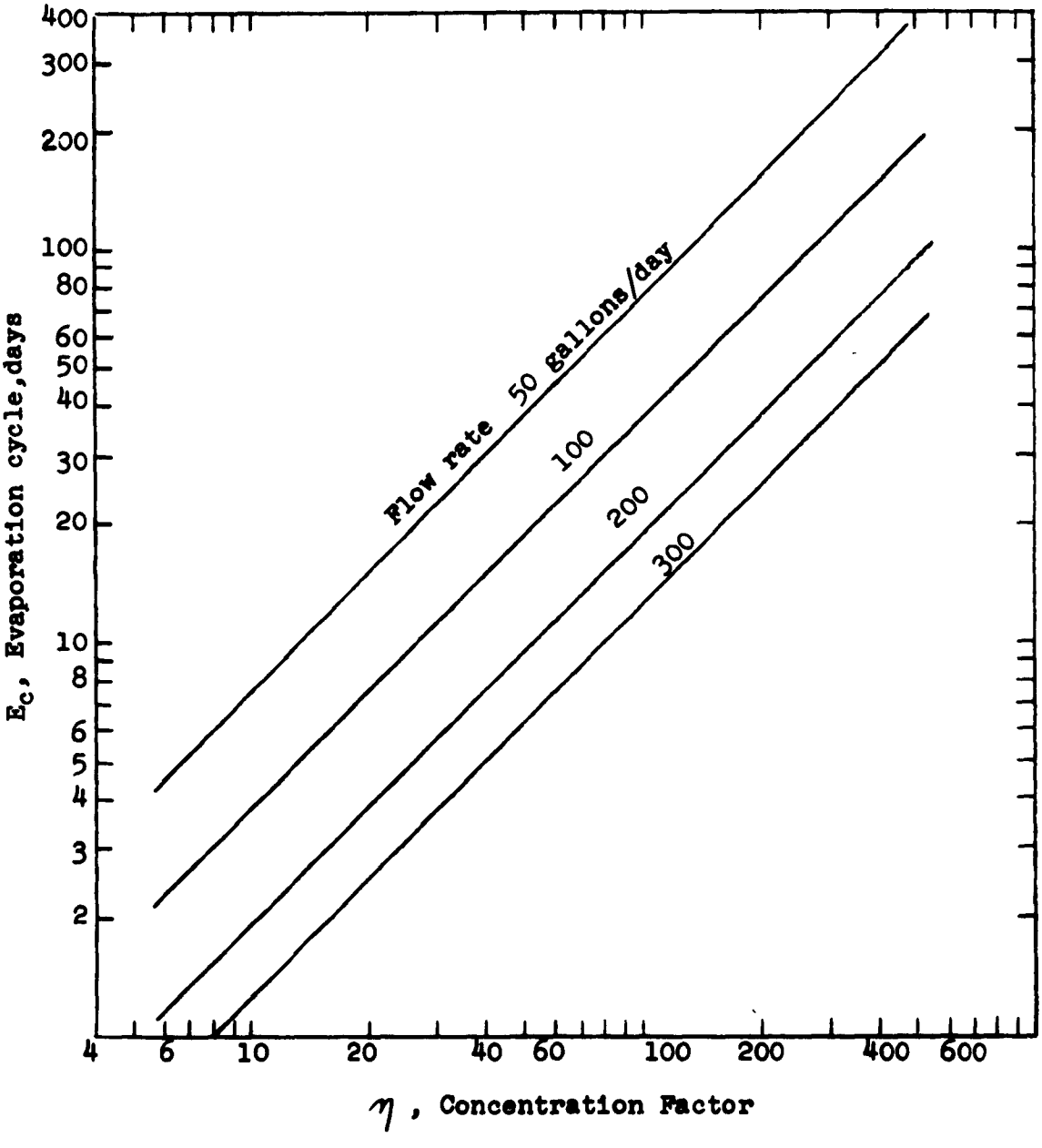


Figure 6

EVAPORATION CYCLE AS A FUNCTION OF THE CONCENTRATION FACTOR



The evaporation cycle E_c is defined as the time required to fill the evaporation drum with concentrated residue; $E_c = t_c$ .38 for this specific design, since the volume of solution in the evaporation drum is 38 gallons.

Using equation 3,

$$E_c = 38\ t_c = 38\ \frac{\eta}{F}$$

Figure 6 is a plot of the evaporation cycle versus the concentration factor.

For example, for a feed flow rate of 300 gallons/day, feed concentration of 2 g/liter and final residue concentration of 500 g/liter, the concentration factor is $\eta = 250$ and from Figure 6 the evaporation cycle is found: $E_c = 63.5$ days or 13 weeks (5 days per week).

5.3 Solution Boiling Point and Steam Temperature

The boiling point of the solution in the evaporator and the steam temperature determine the temperature gradient ΔT. The temperature gradient is one of the three factors which effect the rate of heat input (the other two are heat transfer area and overall heat transfer coefficient).

The boiling point at the beginning of an evaporation cycle will be approximately 212°F. As the concentration of the solution in the evaporator increases the boiling point increases.

It is very difficult to determine the boiling point corresponding to each concentration due to the unknown composition of the feed solution. However, assuming that the final concentration in the evaporator is 500-1000 grams per liter, and judging from the boiling points of various inorganic solutions at these concentrations, a maximum boiling point of 290°F may be assumed.

Since the boiling point of the solution can reach 290°F the condensation temperature of the steam should be higher than approximately 300°F. Figure 7 shows the condensation temperature, t_b, and latent heat of condensation, λ, of steam as a function of pressure. It can be seen in Figure 7 that steam at approximately 65 psia condenses at 300°F.

Since steam at 100 psia is available at most facilities where the evaporator will be used, the unit was designed for this steam pressure. However, it may be stated that the unit designed for 100 psia steam may also be operated with 80 to 150 psia steam. When 80 psia steam is used, the feed flow rate will have to be decreased. With 150 psia steam the evaporator will be able to handle higher feed flow rates.

5.4 Radioactivity Levels

A material balance for the radioactivity yields:

$$F \cdot a_F \cdot t = R \cdot a_R ; = a_R = \frac{F}{R} \cdot a_F \cdot t$$

$$F \cdot x_F \cdot t = R \cdot x_R ; \frac{Ft}{R} = \frac{x_R}{x_F} = \eta$$

$$\therefore \quad a_R = \eta \cdot a_F \qquad (5)$$

Figure 7

STEAM CONDENSATION TEMPERATURE AND LATENT HEAT AS A FUNCTION OF STEAM PRESSURE

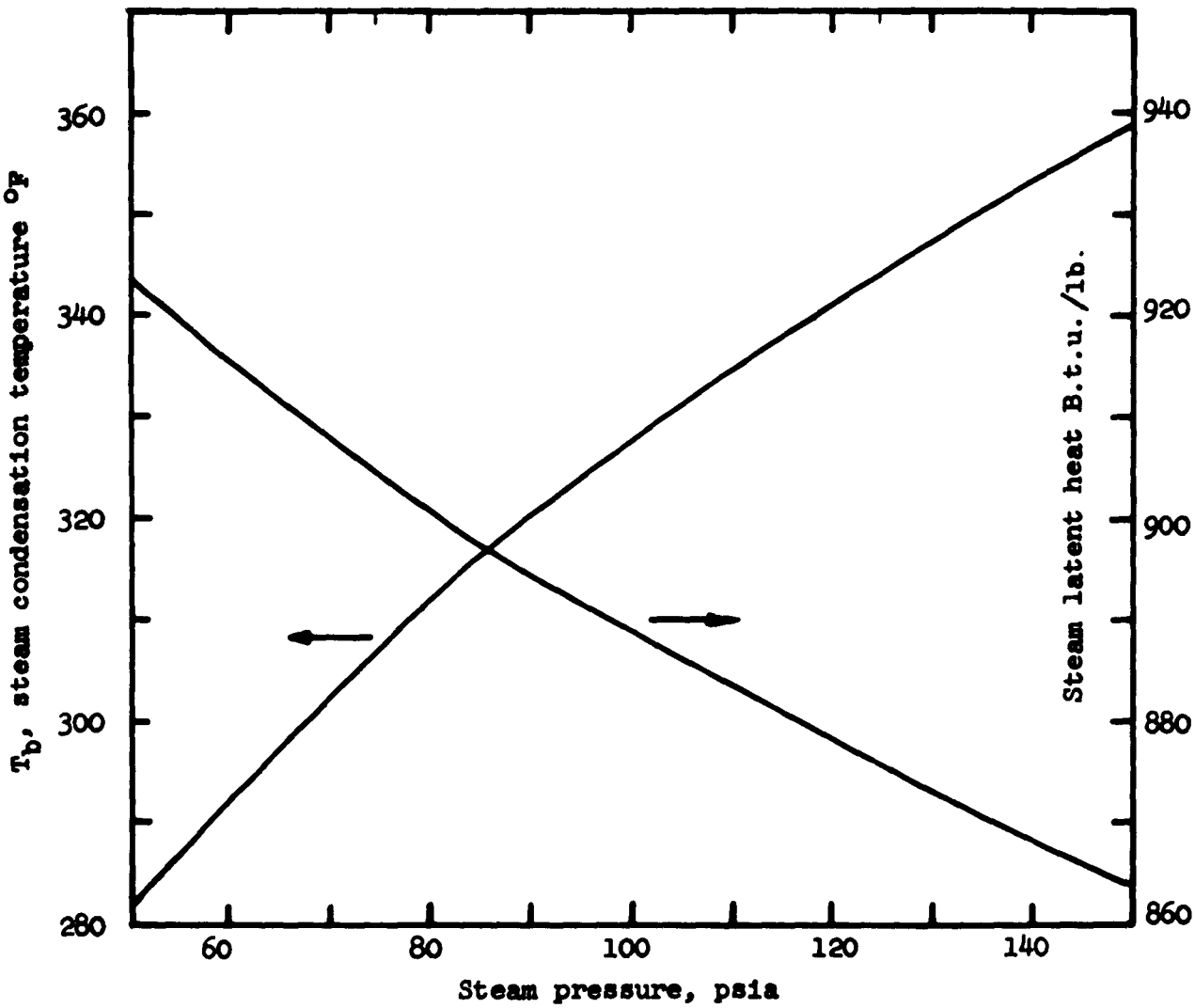


Figure 8 shows the activity levels in the residue as a function of the concentration factor.

As a numerical example let us assume that the feed contains 2 g/l (0.2%) solids, 0.01 μc/ml activity and the final concentration of the residue is 500 g/l.

$$\eta = \frac{500}{2} = 250$$

and the activity in the residue will be (see Figure 8) 25 μc/ml residue or 9.50×10^{-2} curies per gallon of residue.

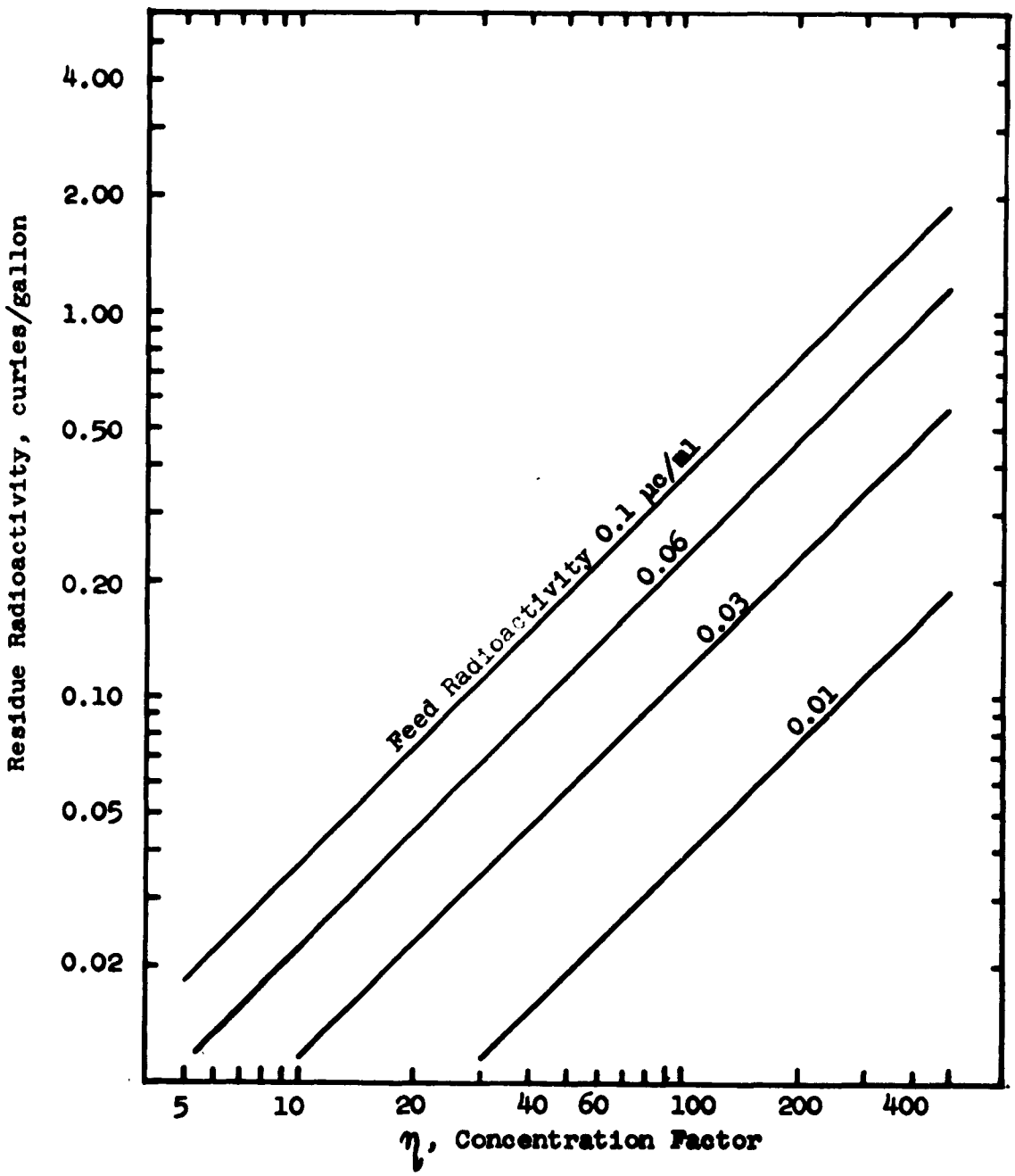
The accumulated radioactivity in the residue is important in connection with the radiation hazard and shielding requirements. In addition, activity above the permissible level may involve some complications in operation and maintenance.

Considering as the worst possible case a feed containing cobalt-60 as radioactive solute, calculations* indicate that the maximum permissible residue concentration of Co^{60} in drums 22" diameter x 34" high is 30-90 μc/gal. This situation represents an extreme case. It is the authors' opinion that shielding will be required only with feeds containing relatively high concentrations of radioactive isotopes emitting high energy gamma rays.

*The calculations are based on 100 mr/40 hour week, 1 foot from the evaporator.

Figure 8

RESIDUE RADIOACTIVITY AS A FUNCTION OF THE CONCENTRATION FACTOR



6. OPERATING INSTURCTIONS

6.1 Installation of Evaporation Drum

1. Place evaporation drum E-1 on cart E-12.

2. Place heating jacket E-2 on evaporation drum and tighten connecting screws.

3. Roll cart E-12 into position. Note that the openings in the drum are approximately in the proper positions.

4. Lock cart to frame by placing the three hooks located on cart E-12 into the rings on the steel frame.

5. Connect the 3" vapor line, entrained liquid return line, feed line, steam line, liquid level controller and temperature indicator to drum cover.

6. Connect steam and condensed steam lines to drum and jacket.

6.2 Starting Operation - Automatic Control

Before starting, check that all the valves are closed.

1. Fill feed tank E-8 with feed solution.

2. Close the main electrical switch on central control panel.

3. Check pH of the feed and adjust to between 6.0 and 8.0 if necessary using a small bottle containing concentrated NaOH or HCl solution. The feed can then be mixed by circulation through pump P-1.

4. Close electrical circuit of liquid level controllers I-7 and I-9.

5. Close electrical circuits of liquid level alarm I-8 and high pressure alarm I-6.

6. Open the valves on both sides of one of the feed filters SVF-4.

7. Open the valve bypassing the feed rotameter I-11. (Do not open the valve bypassing the solenoid valve SVF-2).

8. Open the two valves on both sides of the solenoid valve SVF-2.

9. Start the flow of cooling water to the condenser.

10. Start feed pump P-1.

11. Open the main steam valve located before the solenoid valve SVF-1.

12. Adjust the pressure regulator I-14 until pressure indicator I-15 reads 100 psi (or other predetermined pressure).

13. Open the 3 valves located after the steam rotameter I-10 (do not open the valve bypassing the steam rotameter).

14. Carefully open the needle valve in front of the steam rotameter I-10, and adjust the steam flow rate to approximately 400 lbs/hr.

15. Open the two valves on both inlet and outlet of the condensate pump P-2.

16. Open the four valves on both sides of one of the activated carbon cartridges and one of the ion exchanger cartridges.

The unit is now operating automatically at full capacity.

6.3 Starting Operation - Manual Control

1. Proceed with steps 1 to 6 as listed under automatic control.

2. Open the globe valve on back of feed rotameter I-11.

3. Proceed with steps 8 to 10 as listed under automatic control.

4. Regulate the feed flow rate with the needle valve located in front of feed rotameter I-11 until the rotameter reads 45 gal/hr.

5. Proceed with steps 11-16 as listed under automatic control.

6. When the solution in the evaporation drum starts to boil adjust the feed flow rate so that the feed solenoid valve does not close and the feed rotameter continuously reads 45 gal/hr.

The unit is now operating manually at full capacity.

6.4 Shut Down

1. Close the main steam valve.

2. Stop feed pump P-1.

3. Close all valves on steam line.

4. Close all valves on feed line.

5. When condensate stops flowing into the intermediate condensate tank E-5, or if the intermediate condensate tank is empty, stop condensate pump P-2 and close all valves on the condensate lines.

6. Open the main electrical swtich.

6.5 Removal of Evaporation Drum

In removing the evaporation drums special care must be exercised to avoid any spillage of the concentrated residue. Residue may be spilled when the liquid level controller probe I-7 and temperature indicator I-3 are removed. These two instruments must be lifted vertically and screwed immediately into protection sleeves. These sleeves are to be made from 1-1/2" stainless steel pipes with welded closures at the bottoms and equipped with appropriate couplings on top. After the evaporation drum is removed from the unit, I-3 and I-7 can be removed from the protection sleeves and washed into stainless steel cans. The wash solution can be poured into the feed tank E-8.

Step by step procedure:

1. Disconnect all flexible tubes leading to the evaporation drums and plug all openings.

2. Remove liquid level controller I-7 and temperature indicator I-3 as described above.

3. Close all openings with appropriate plugs and caps.

4. Unlock cart E-12 and roll it out of the unit.

5. The evaporation drum can be lifted from the cart E-12 using a fork lift truck with a suitable drum-lift attachment.

7. DESIGN DETAILS

Most of the equipment to be used in the concentrator unit are commercially available items. Those components requiring special fabrication are the evaporation drums E-1, feed and condensate tanks E-8 and E-9, intermediate condensate tank E-5, steel frame E-11, and central control panel E-10. A complete list of equipment including detailed specifications is presented in Section 8 of this report.

7.1 General Arrangement

The general arrangement of the equipment is shown in detail in drawing D-1.

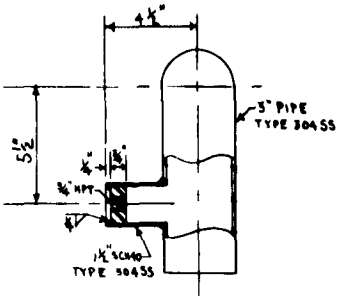
For installation please note:

a. Feed tank E-8, condensate tank E-9 and intermediate condensate tank E-5 should be maintained at approximately 2" water vacuum controlled by a fan and exhaust system which would vent any gaseous material through an absolute filter. This will prevent activity from leaking into the working environment. The exhaust system should be connected to the tanks with 1/2" copper tubes.

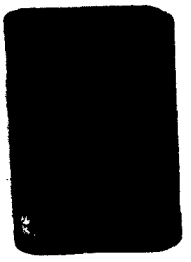
b. All hot areas should be thermally insulated.

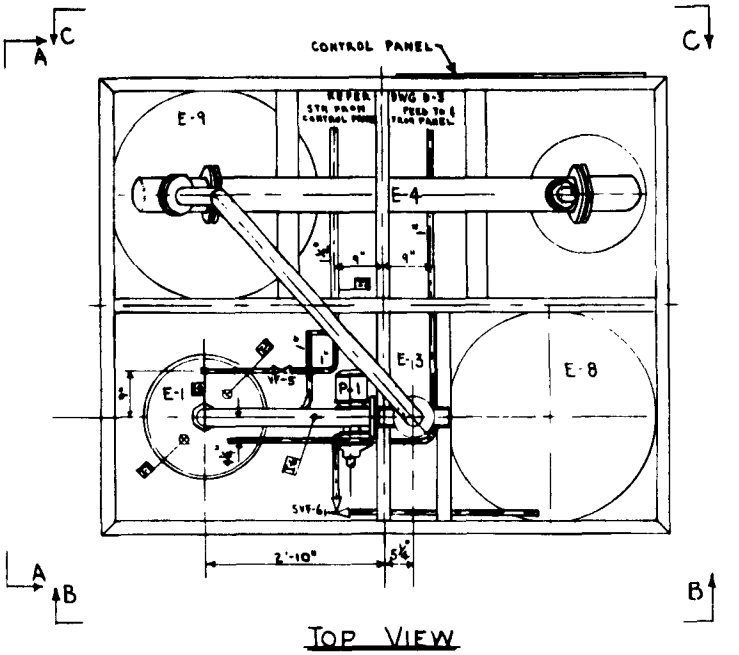
c. Stainless steel sampling valves (1/2" or 3/4", not listed in Figure 9) should be installed in the appropriate openings provided near the bottom of tanks E-5, E-8 and E-9.

Drawing D-1 shows in some detail the arrangement and location of pipes and valves. For general orientation refer to Figure 9. Specifications for the various valves are listed in Section 8 (VF-1 to VF-7).

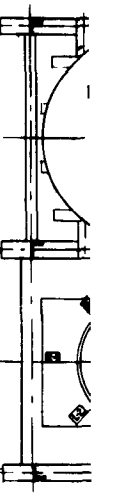


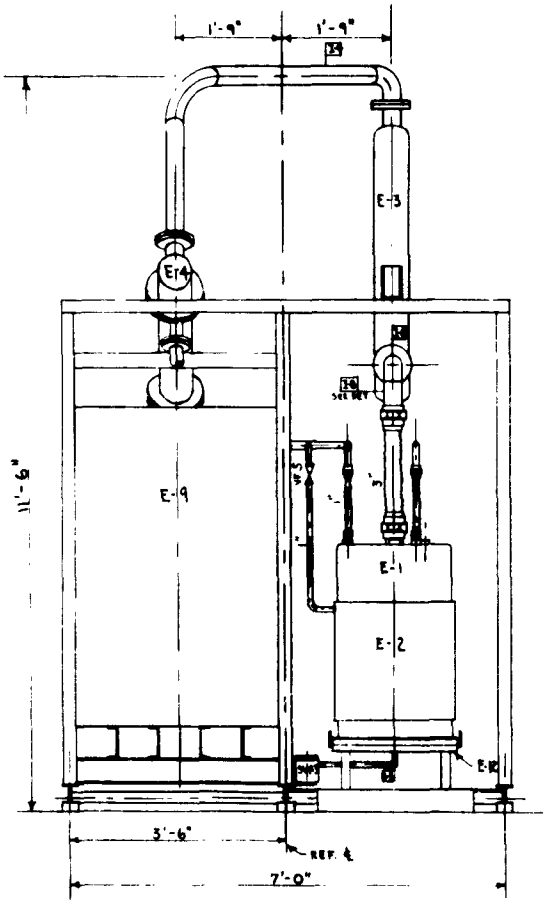
DETAIL CONN. I-8



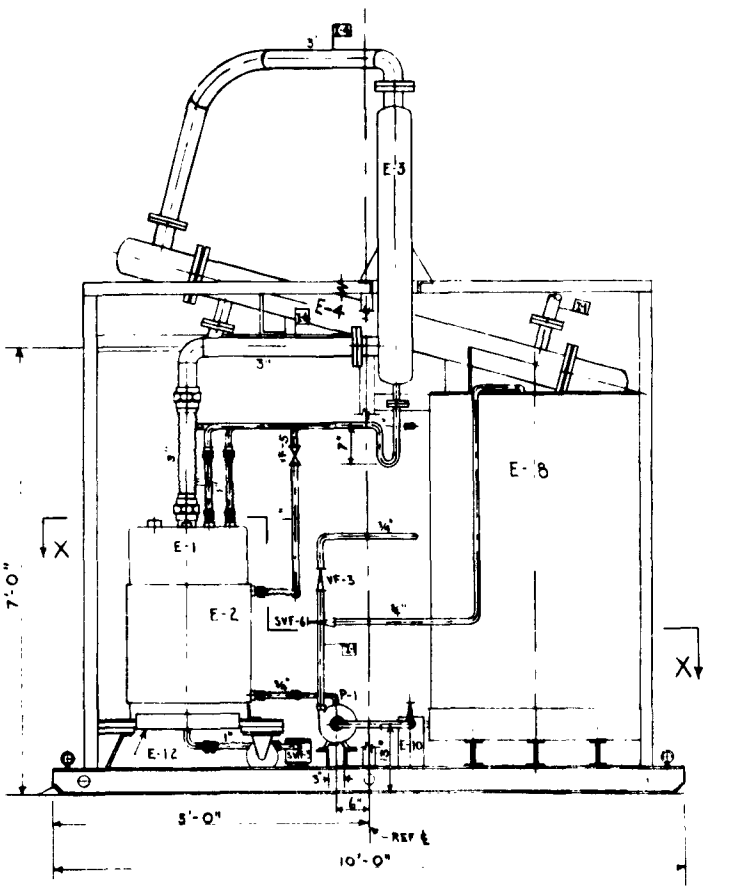


TOP VIEW

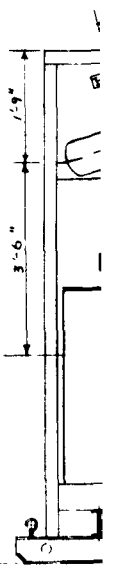




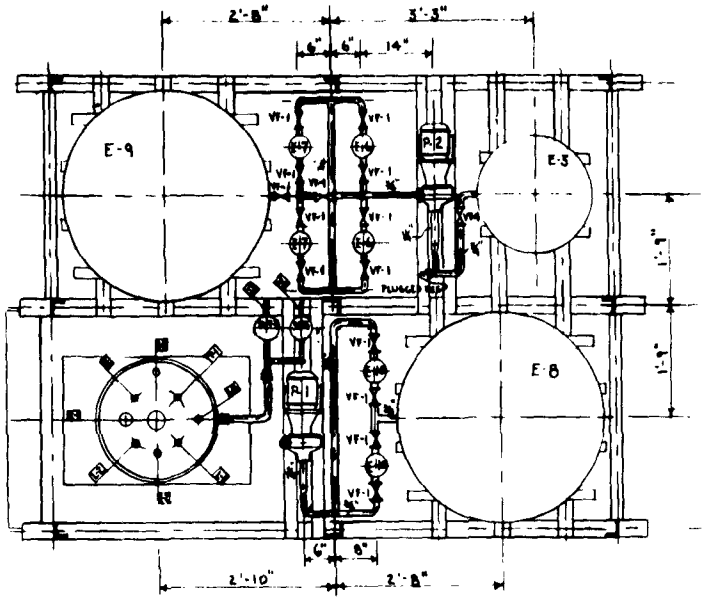
VIEW A-A



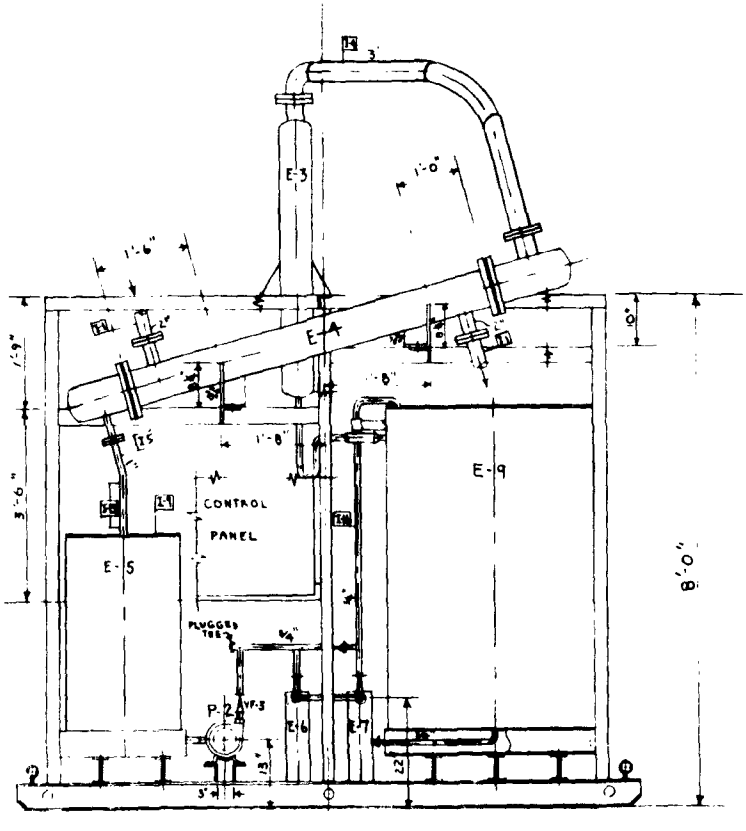
VIEW B-B



REFERENCE DRAWINGS
C.S. EVAPORATOR B-1
C.S. EVAPORATOR DETAILS B-2
FRAME D-2
CONTROL PANEL D-3



SECTION X-X



VIEW C-C

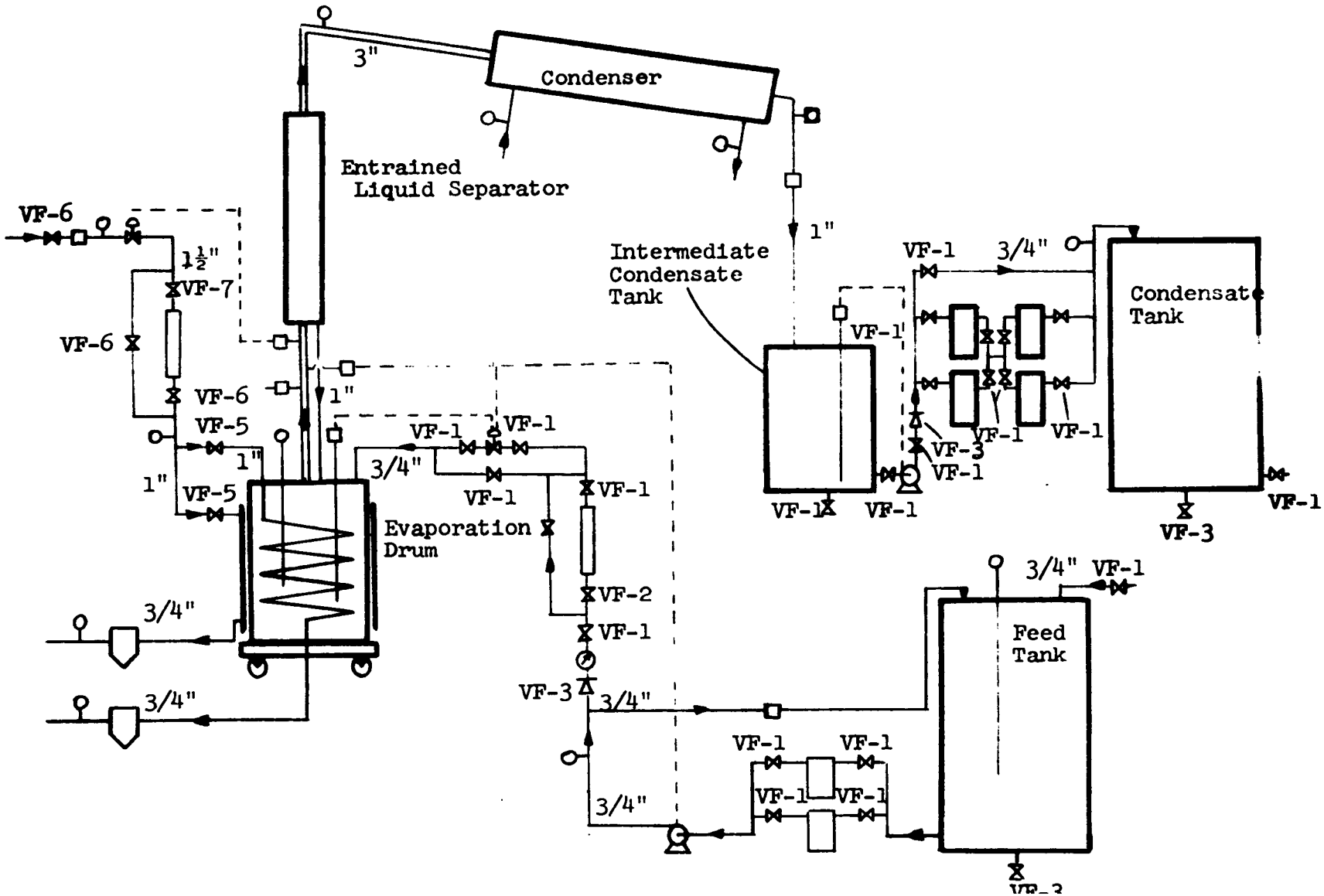
NOTES

1 MOVE ASSEMBLY ONLY WHEN EQUIPMENT IS EMPTY.
2 GUIDE & SUPPORT PIPING, INSTRUMENTS, TRAPS, FILTERS ETC., FROM FRAME AS REQ'D.
3 BOLT ALL EQUIPMENT SECURELY TO FRAME. DRILL BOLT HOLES IN FRAME TO SUIT EQUIPMENT. USE MIN ⅜" DIA BOLTS FOR E-8 & E-9.

RADIATION APPLICATIONS INC.
GENERAL ARRANGEMENT
LOW LEVEL
WASTE CONCENTRATOR
DR. AJK 2-4-63
CKD Kamba 2-9-63 DWG. D-1

Figure 9

Flow Diagram for Radioactive Waste Concentrator (Valves and Pipe Sizes Designated)



7.2 Specially Fabricated Items

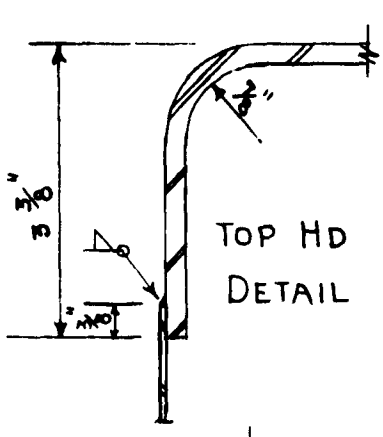
7.2.1 Evaporation Drums E-1. The detailed design of the evaporation drums is shown in Drawings B-1 and B-2. The drawings include details of drums with welded heads and drums equipped with one removable head. For the prototype test unit the drums with removable heads should be used.

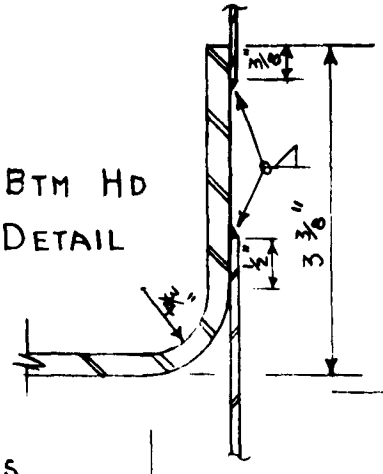
7.2.2 Feed and Condensate Tanks, E-8 and E-9. The design of the feed and condensate tanks is shown in Drawing B-3. During assembly of the unit, 4 holes are to be drilled through the carbon steel ring located on the bottom of the tanks and through the supporting beams on the steel frame E-11.

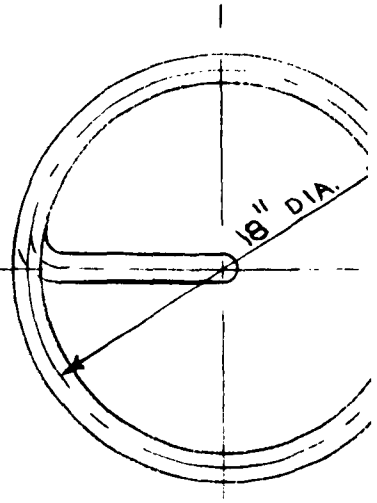
7.2.3 Intermediate Condensate Tank E-5. The intermediate condensate tank has the same general design as the feed and condensate tanks except for size. See detailed specifications (Section 8).

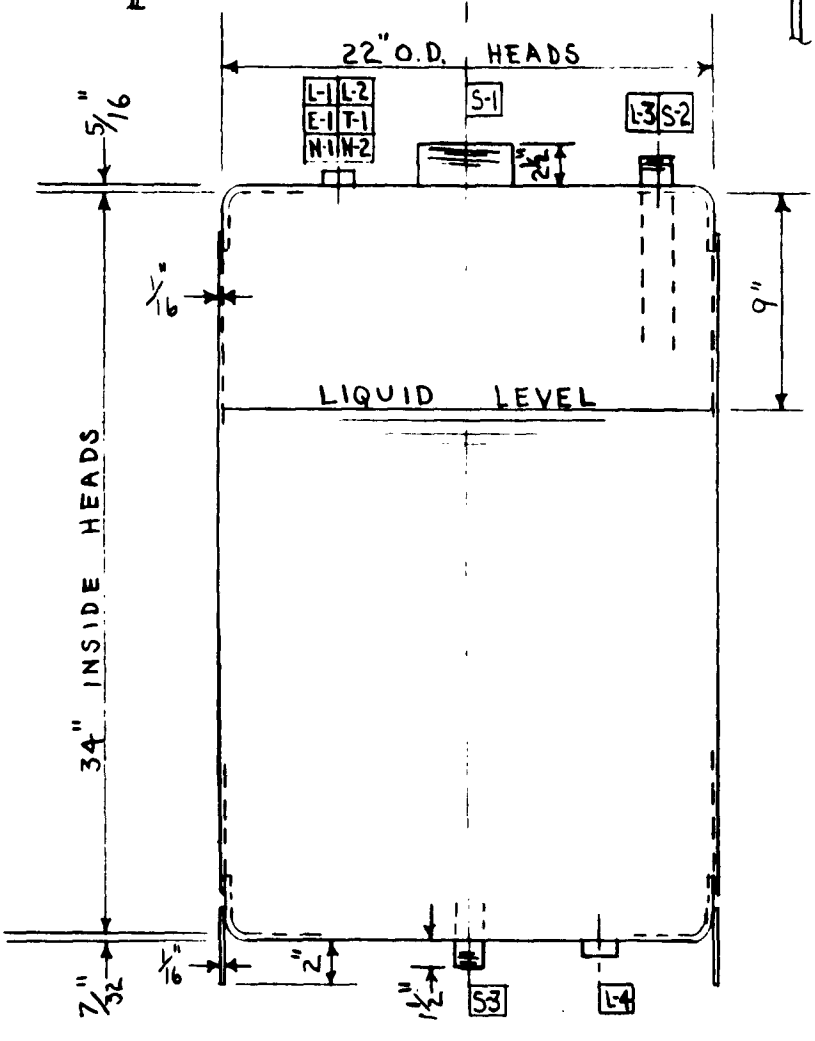
7.2.4 Steel Frame E-11. The detailed design of the steel frame is shown in Drawing D-2.

7.2.5 Central Control Panel. The general design of the central control panel is shown in Drawing D-3. The needle valves VF-2 and VF-7 located before the feed and steam rotameters I-11 and I-10 are to be installed on the control panel.



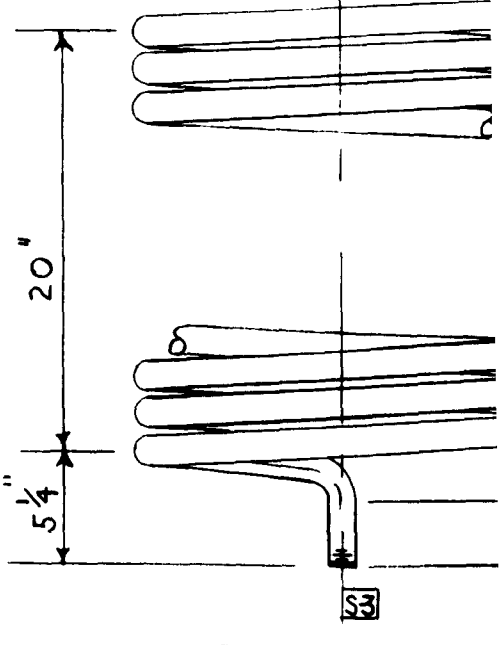






DRUM

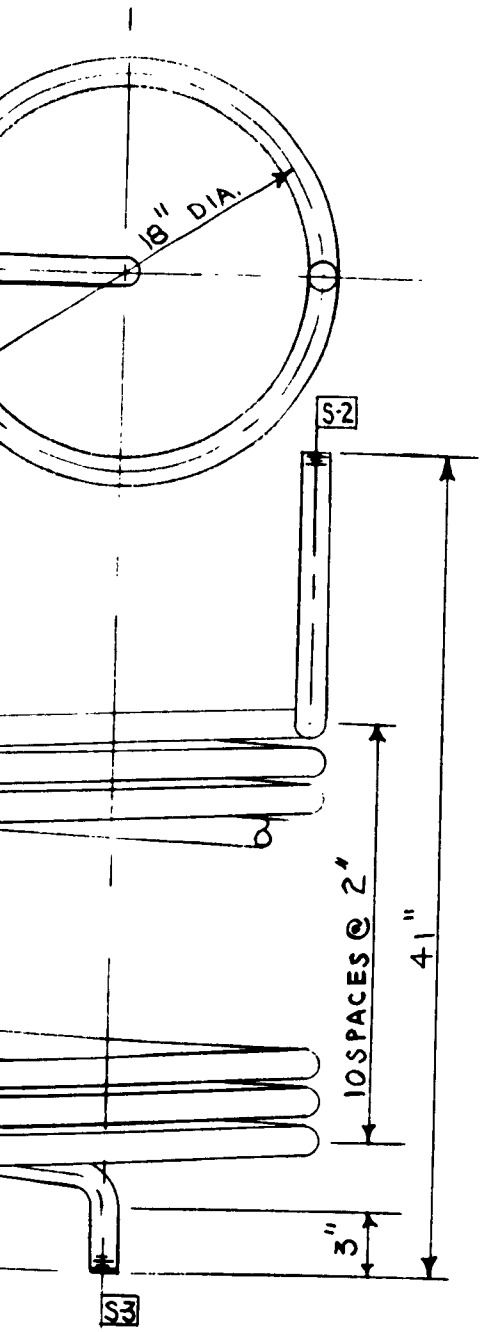
SA-285 GR.C F.B.Q.



PIPE COIL

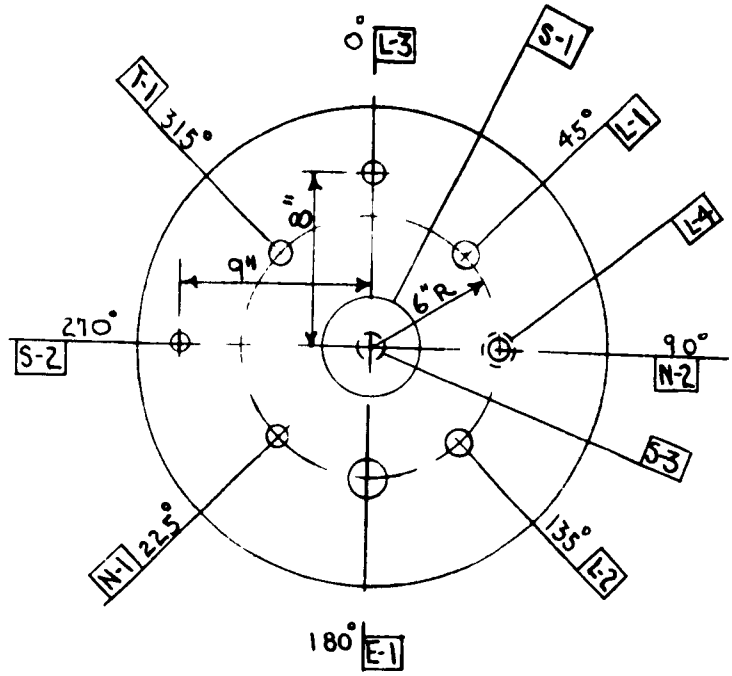
1" SCH 40 SA-53 GR.B

ALT. TOP HEAD DESIGN - REFER DWG. B-4



IPE COIL

+O SA-53 GR.B OR SA-106 GR.B



TOP PLAN

NOTE- S-3 & L-4 ON BTM HD

DESIGN COND. 5 lb/in² 290°F

CORROSION ALLOW. .03125" MIN.

TEST - HYDRO. TEST COIL TO 300 lb/in²
BEFORE INSTALLING IN DRUM.
HYDRO. TEST DRUM TO 8 lb/in²

WEIGHT EMPTY 2601b OPER. 6301b

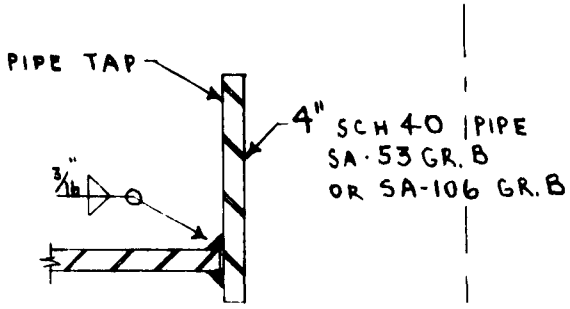
RADIATION APPLICATIONS INC.

EVAPORATOR E-1

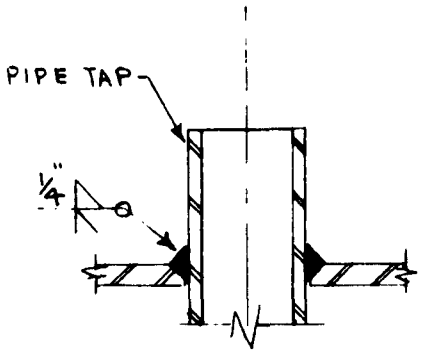
DR. AJK 12-1-62

CKD. Karalus 2-9-63 DWG. B-3

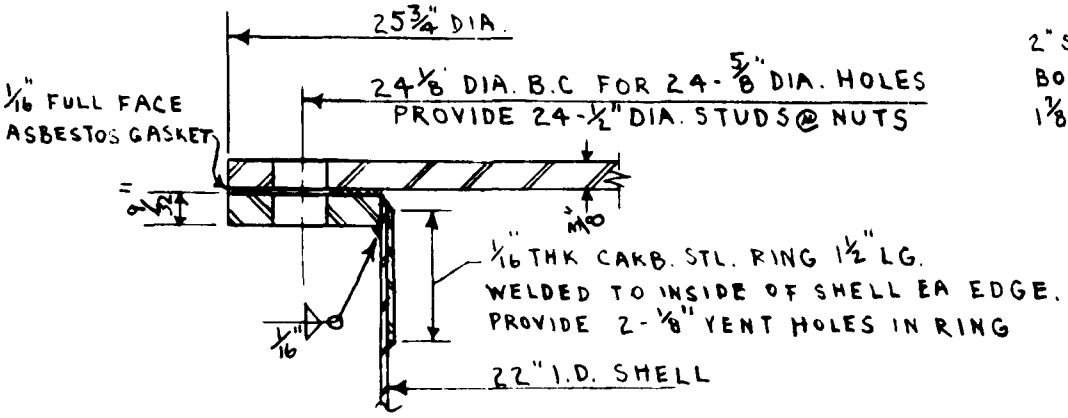
REF. DWG. EVAP. DETAILS B-4



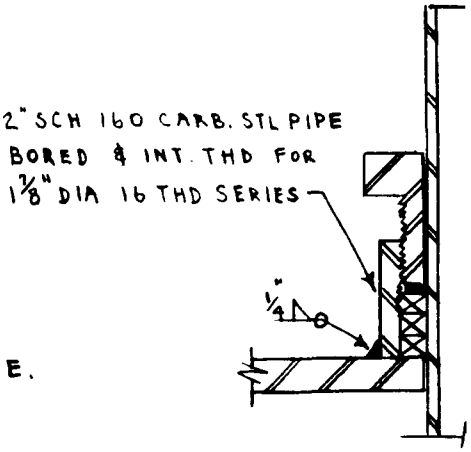
DETAIL S-1



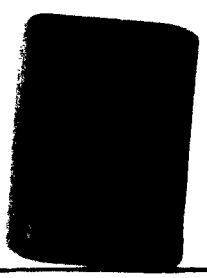
DETAIL S-2 & S-3



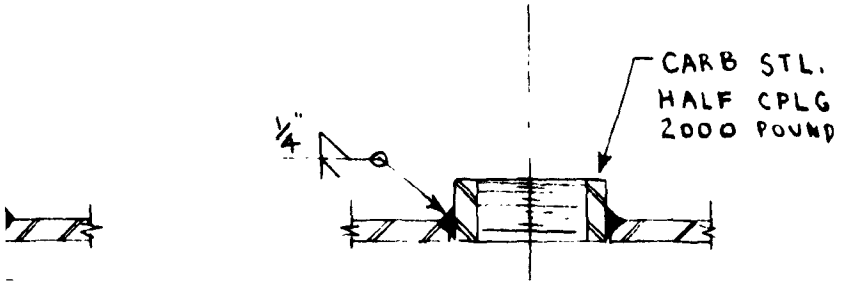
ALT. TOP HD. DESIGN DETAIL



DETAIL S-2 FO



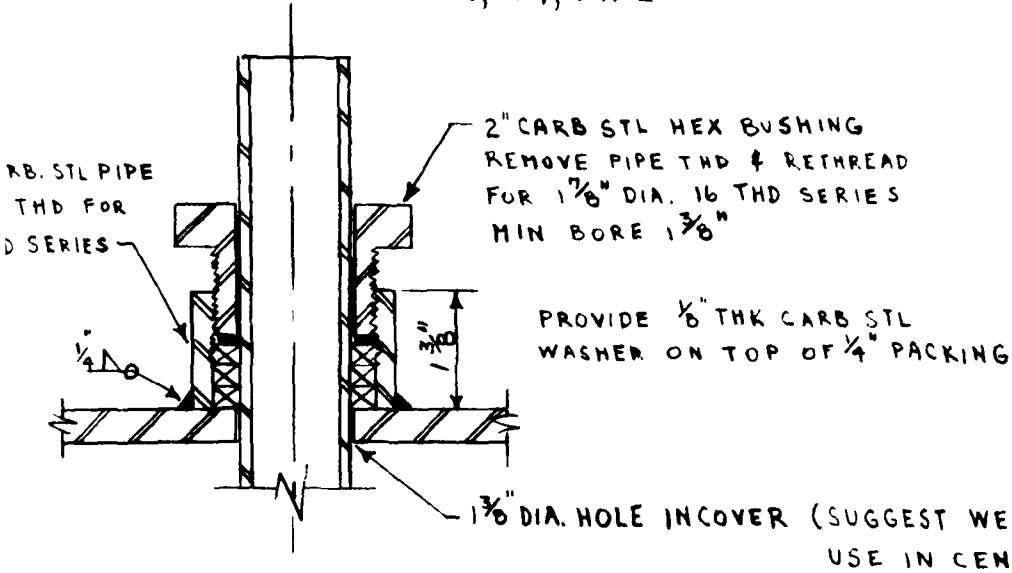
CONN.	SIZE	RTG	SERVICE
S-1	3"	PIPE	STEAM OUTLET
S-2	1"	PIPE	HEATING STM INLET
S-3	1"	PIPE	CONDENSATE OUTLET
L-1	1"	CPLG	LIQUID INLET
L-2	¾"	CPLG	LIQUID LEVEL CONTROL
L-3	1"	CPLG	ENTRAINED LIQUID RETURN
L-4	1¼"	CPLG	FUTURE LIQUID OUTLET
T-1	1"	CPLG	TEMPERATURE
E-1	1½"	CPLG	ELECTRIC HEATER
N-1	1"	CPLG	FUTURE
N-2	1½"	CPLG	FUTURE



2 & S-3

DETAIL L-1, L-2, L-3, L-4,
T-1, E-1, N-1, N-2

NOTE ÷ PROVIDE PIPE PLUG E-1,
L-4, N-1, & N-2



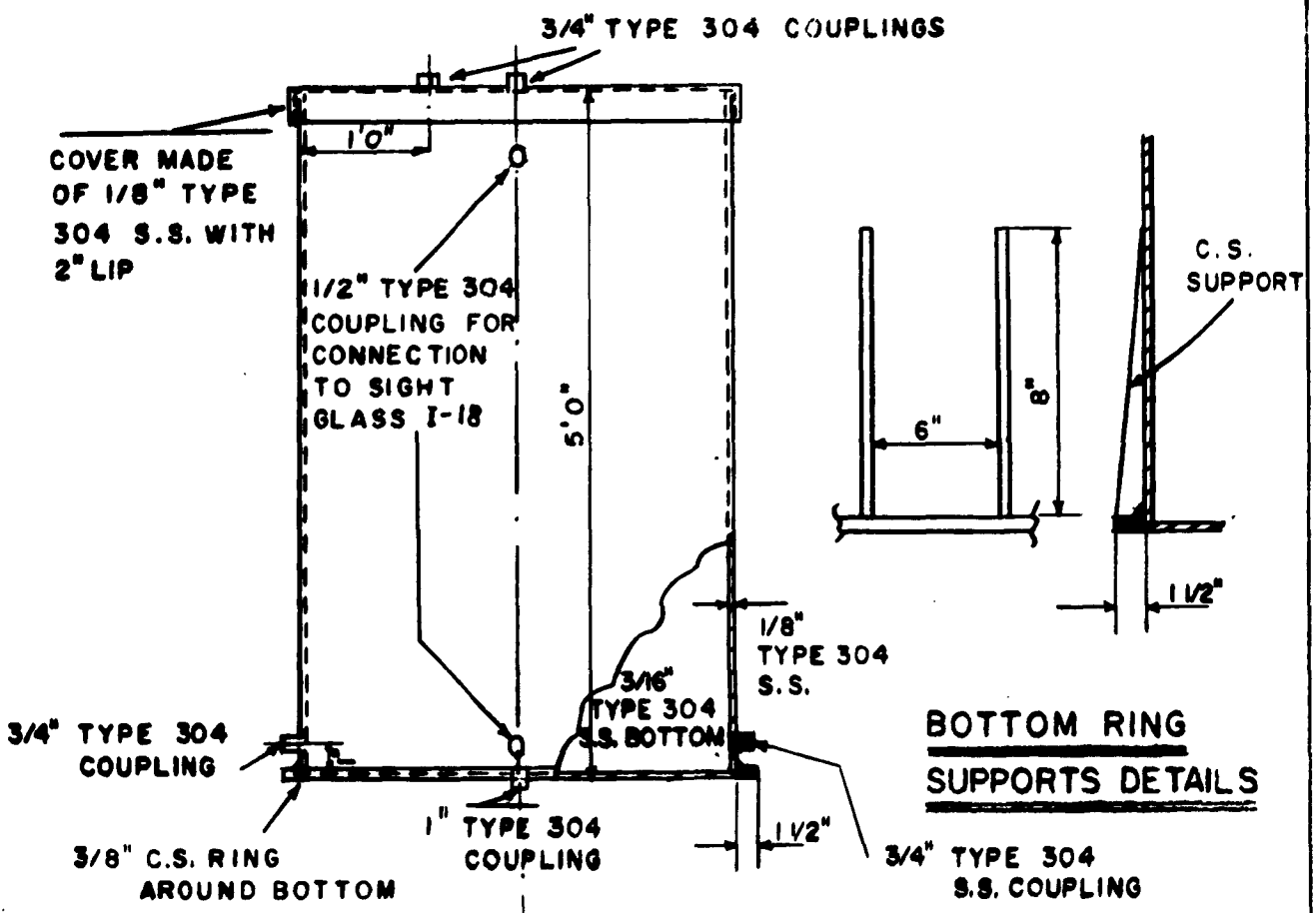
ETAIL S-2 FOR ALT. TOP HD DESIGN

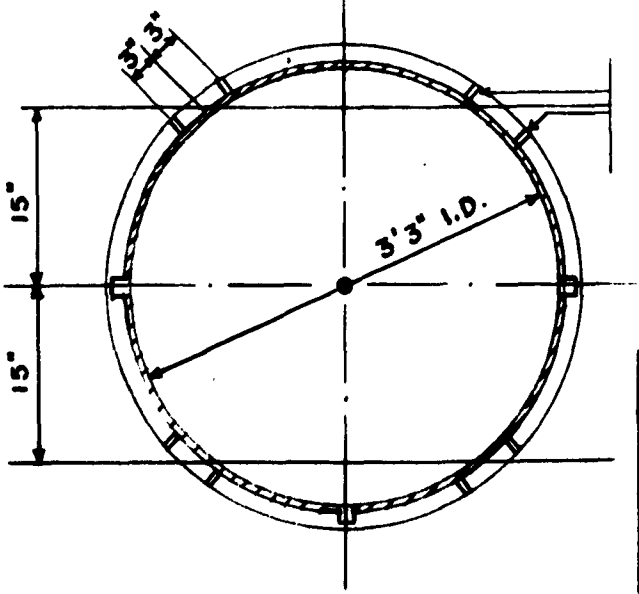
RADIATION APPLICATIONS INC.

EVAPORATOR DETAILS

DR. AJK 12-1-62

CKD. Karalis 2-9-63 DWG. B-2



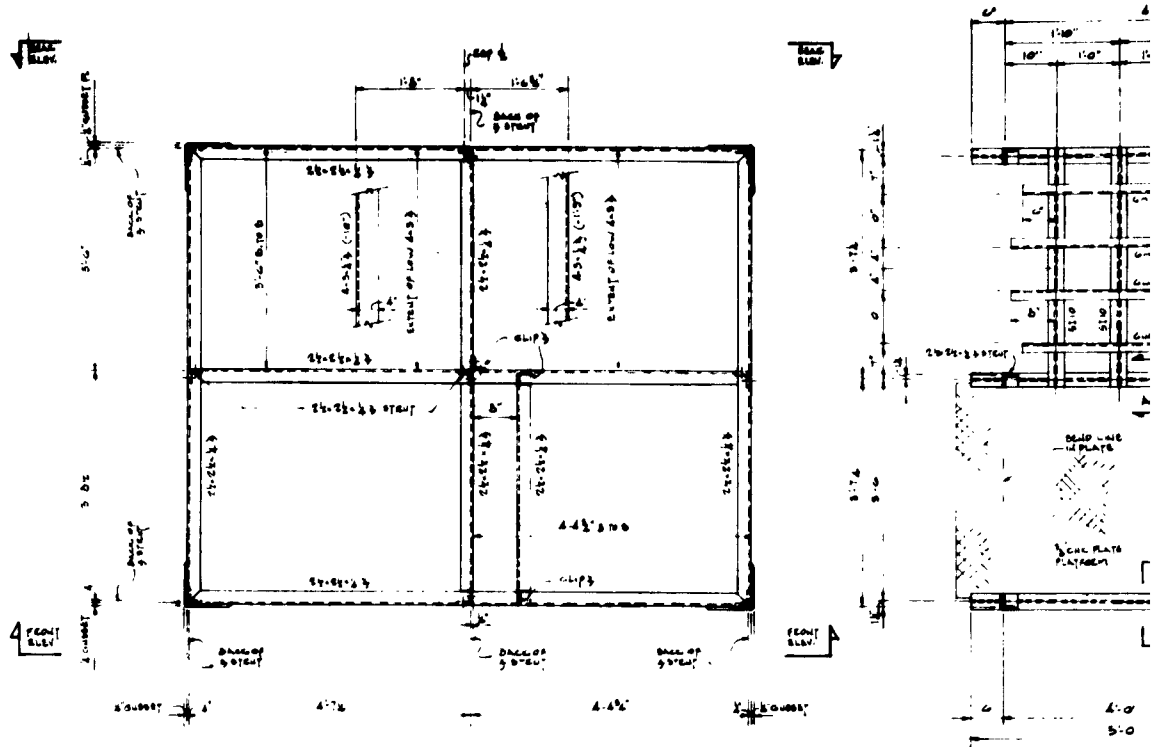


RADIATION APPLICATIONS INC.

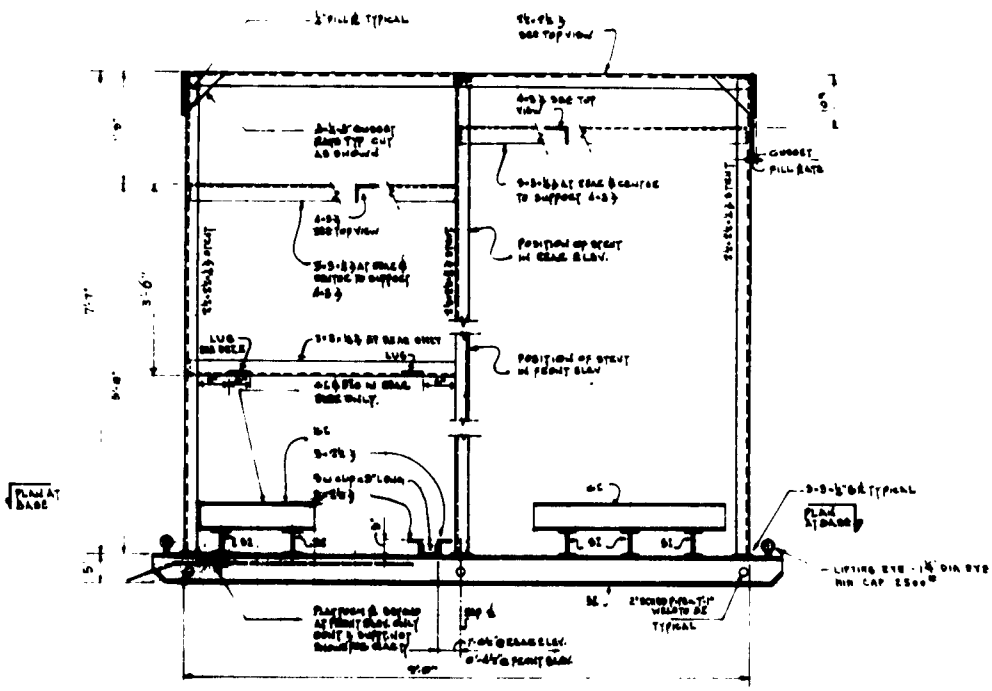
FEED AND CONDENSATE TANKS DETAILS

J.S.S.

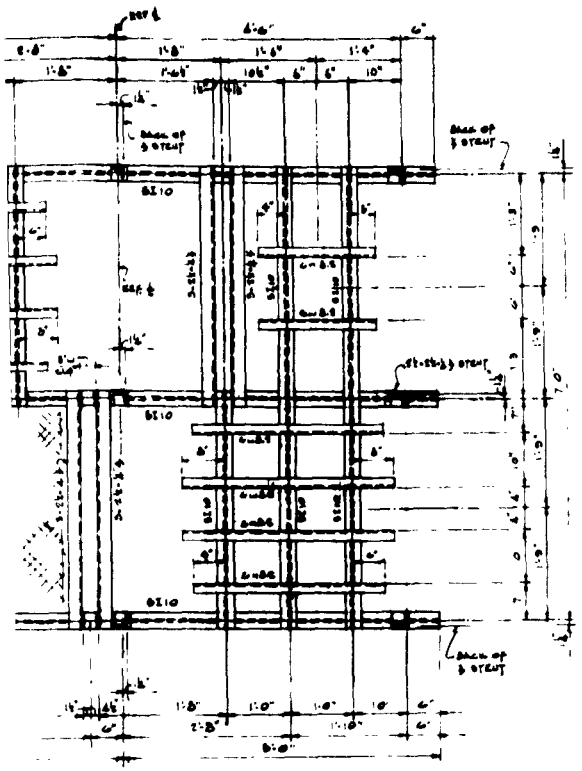
DWG B-3



TOP VIEW



FRONT ELEVATION (REAR ELEV. SIMILAR AS NOTED)



LAN AT BASE

PS AT BASE NOT SHOWN FOR CLARITY

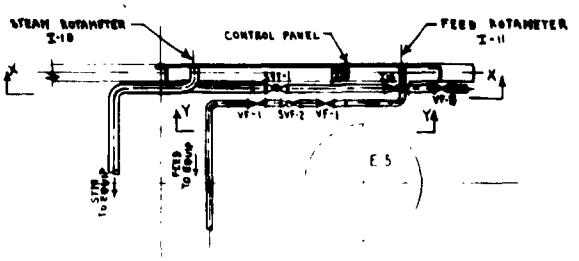
A-A

DETAIL X

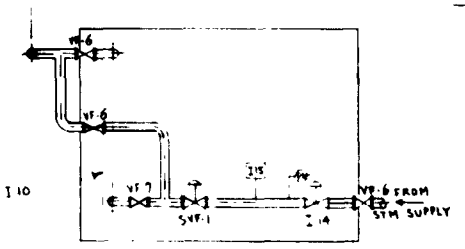
LUG DETAIL

EST WT FRAME 2350#

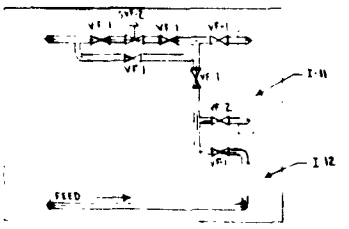
RADIATION APPLICATIONS INC.	
WASTE CONCENTRATOR FRAME E-11	
DR R.D. 2-8-63	
CKD. Kendin 2-9-63	DWG. D-2



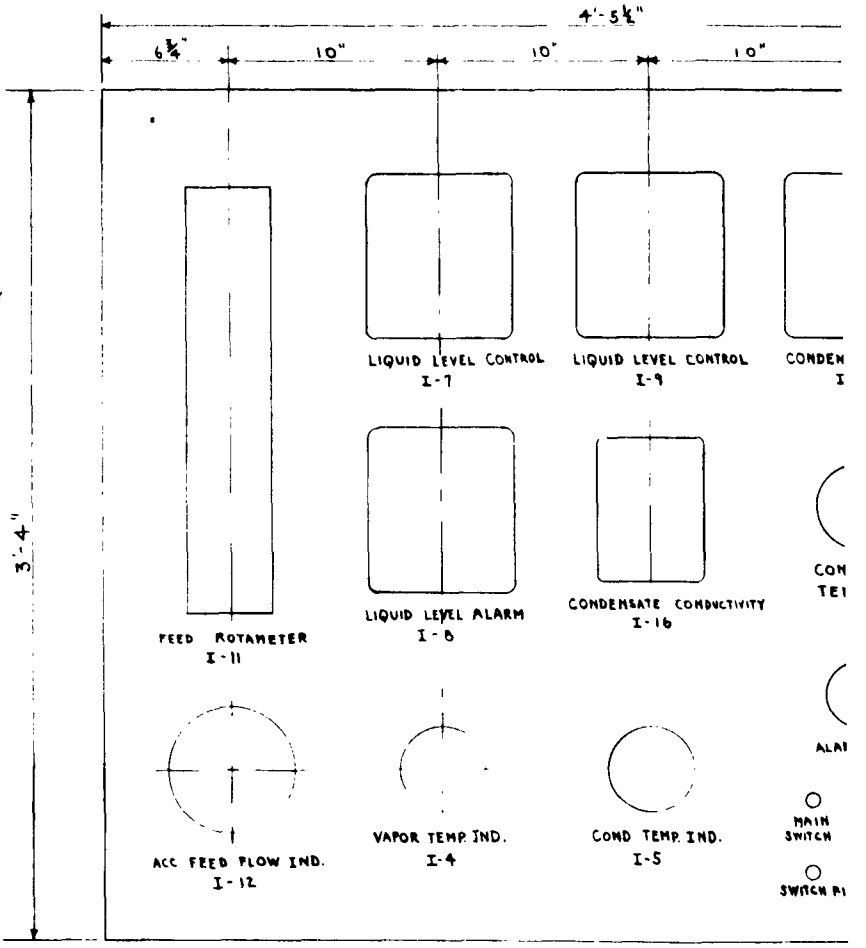
PIPING PLAN AT CONTROL PANEL



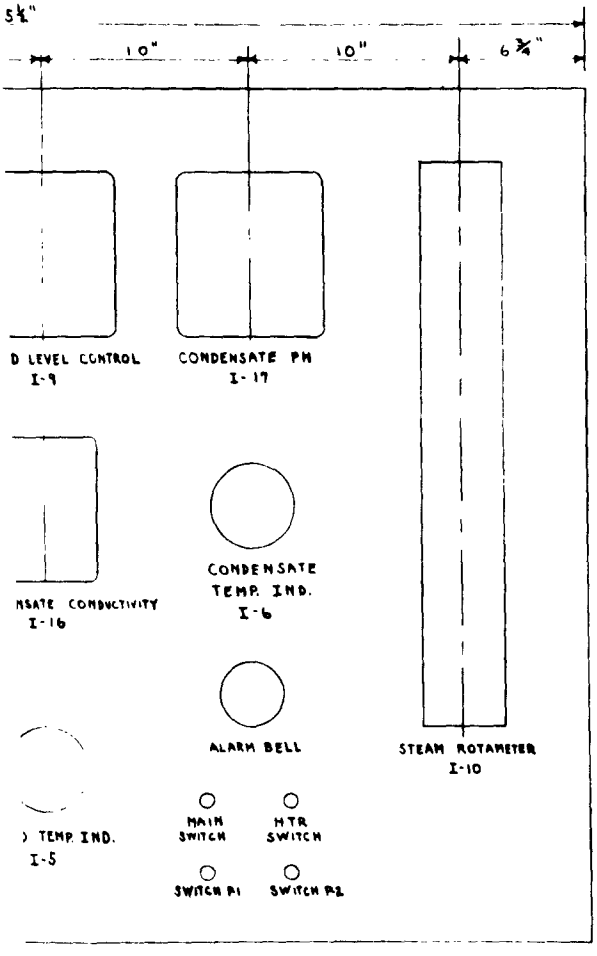
VIEW X-X STM PIPING



VIEW Y-Y FEED PIPING



FRONT VIEW CONTROL PANEL



CONTROL PANEL

NOTES

1 PANEL BOARD MATERIAL A-7 OR A-283 GR D FBQ ¼" THK

2 BOLT PANEL BOARD TO FRAME WITH ½" DIA MACHINE BOLTS ON 12" CENTERS

RADIATION APPLICATIONS INC.	
CONTROL PANEL	
DR AJK 2-10-63	
CKD	DWG. D-3

8. DETAILED EQUIPMENT SPECIFICATIONS

E-1 Evaporator Drum

Supplier: Elicott-Brandt, Inc.
1700 Ridgely Street
Baltimore 30, Maryland

Quantity: 2

Model: -

Price: $435 each; $ 870 total.

Specifications: Carbon steel drums with removable head as per design drawings B-1 and B-2. Drums should be tested at 8 psig, steam coil at 200 psig. Total volume of solution in drums: 38 gallons.

E-2 Drum Jacket, Steam Heated

Supplier: Dean Products, Inc.
616 Franklin Avenue
Brooklyn 38, N.Y.

Quantity: 1

Model: CL-22, with embossing on 12 gage back sheet

Price: $185.45

Specifications: Clamp type "Panel coil" 22-1/4" I.D., 22" high, 14 cold rolled steel with embossing on 12 gage back sheet. 1" steam inlet connections, 3/4" condensate outlet connections.
Maximum steam pressure: 150 psig.

Instructions for Ordering: Model No. CL-22 clamp type "Panel coil" 22-1/4" I.D., 22" high, 14 gage cold rolled steel with embossing on 12 gage back sheet.
Maximum steam pressure: 150 psig.

E-3 Entrained Liquid Separator

Supplier: York Separators, Inc.
8 Central Avenue
West Orange, New Jersey

Quantity: 1

Model: As per drawing SB-1469

Price: $357

Specifications: York radioactive waste separator vessel designed to remove entrainment from a radioactive waste evaporation system as shown on drawing SB-1469. All materials of construction type 304 stainless steel. Designed to handle 350 lbs. per hour of vapor flowing at atmospheric pressure.

Size: Height (overall): 59-1/2"
Diameter: 6"

E-4 Condenser and Subcooler

Supplier: Doyle & Roth Manufacturing Co.
136-50, 24th Street
Brooklyn 32, N.Y.

Quantity: 1

Model: D&R Std. VT 661-6, 32 ft.^{2} Surface.

Price: $820

Specifications: Shell and straight tube, fixed tube sheet vapor condenser. Type 304 stainless steel tube side, single pass shell and tube side. Consisting of a 6-5/8" O.D. steel shell containing 27-3/4" O.D. # 18 BWG type 304 stainless steel tubes, 6 ft. long, 15/16" triangular pitch, 32 ft.^{2} surface. All per D&R drawing No. MA-4174. Supports according to RAI

Specifications: (Continued) drawing No. D-1.

Instructions for Ordering: D&R std. 661-6, 32 ft.^{2} surface.
Supports according to specifications.

E-5 Intermediate Condensate Tank

Supplier: Same as E-4

Quantity: 1

Model: -

Price: $250

Specifications: Same design as shown on drawing B-3 with the following changes:
diameter: 22"
height: 36"
Couplings: cover: 1" on center and 3/4" on side
Bottom: 3/4" on center
Sides: two 3/4" located on opposite sides near bottom.
No supports for bottom carbon steel ring.
Walls and cover made from 1/16" type 304 stainless steel.

E-6 Activated Carbon Cartridges

Supplier: Same as E-7

Quantity: 2

Model: Same as E-7

Price: $115 each; $230 total.

Specifications: Same as E-7 with cartridge filled with activated carbon rather than a nuclear grade ion exchange resin.

E-7 Ion Exchanger Cartridges

Supplier: Penfield Manufacturing Co., Inc.
46 Britania Street
Meriden, Connecticut

Quantity: 2

Model: PM-8A, Pressure Cartridge Demineralizer

Price: $115 each; $230 total.

Specifications: Pressure type monobed demineralizer. Can be used with flow rates of up to 240 GPH with a corresponding pressure drop of 24 psi. At 50 GPH the pressure drop is only 4 psi. Plastic construction with clear sump allowing visual inspection of the nuclear grade exchange resins and is screwed on by hand to permit easy resin replacement.

Dimensions: 4-1/2" diameter, 20-5/8" high.

Connections: 3/4" N.P.T.

Sump capacity: 0.09 $ft.^3$

E-8 Feed Tank

Supplier: Same as E-4

Quantity: 1

Model: -

Price: $500

Specifications: As per drawing D-3

E-9 Condensate Tank

Same as E-8

Quantity: 1

E-10 Central Control Panel

Supplier: None specified

Quantity: 1

Model: -

Price: Estimated $75

Specifications: As per drawing D-3.

E-11 Steel Frame

Supplier: None specified

Quantity: 1

Model: -

Price: approximately $600 (Estimation based on $0.40 per pound).

Specifications: As per drawing D-2

Total weight: 2350 lbs. (estimated).

E-12 Evaporator Cart

Supplier: Carter, Milchman & Frank, Inc.
28-10 37th Avenue
Long Island City 1, N.Y.

Quantity: 1

Model: Bond Universal Lift Jack Platform # 165-2436, and
Bond Universal Lift Jack # 1605.

Price: Platform: $79.60, Lift Jack: $71.60, Total: $151.20.

Specifications: Bond Universal Lift Jack Platform:
1-1/8" thick hard wood platform 24" x 36",
hard vulcanized on rubber tread roller bearing
wheels. Average overall height 9-3/4".
The platform will require the following
provisions (not included in above price):
1/8" - 24" x 36" carbon steel plate to be

Specifications: (Continued)

bolted on platform for protection against spills, countersink bolts for flush surface. Also to be provided are side angles to prevent E-1 from sliding off platform and end angle for positioning E-1. In addition 3 hooks are to be welded to three sides of the cart. These hooks will mate with rings provided in steel frame E-11 to prevent sliding of cart E-12 during operation.

Bond. Universal Lift Jack: 49" overall length center coupling to end of handle, 7-3/4" overall width, 7-7/8" overall height to underside of platform, vulcanized on G-2 roller bearing wheels.

Instructions for Ordering:

See Model

I-1 Temperature Indicator, Bi-Metal

Supplier: Marsh Instrument Co.
1209-11 Anderson Avenue
Fort Lee, New Jersey

Quantity: 3

Model: Master Therm, 273S0X0404

Price: $10.35 each; $31.05 total.

Specifications: Bimetal Thermometer

Dial: 3"

Stem Length: 4"

Connection Unit: 1/2 NPT

Range: 30-240°F.

304 stainless steel construction.

Instructions for Ordering: See Quantity, Model and Specifications.

I-2 Temperature Indicator, Bi-Metal

Same as I-1 but range 50-500°F.

Model: 273S0X0409

Price: $10.35 each; $31.05 total.

I-3 Temperature Indicator, Bi-Metal and Thermometer Well

Supplier: Same as I-1

Quantity: 1 thermometer, 1 well.

Model: Adjustable Master Therm, Model No. 275MAT2408

24" well, Model No. 31658A-24

Price: Thermometer: $33.75; Well: $39, Total $72.75.

Specifications: Bi-Metal Thermometer

Dial: 5-1/2", adjustable type

Stem Length: 24"

Connection: 1/2" NPT Male

Range: 50-400°F.

Specifications: (continued) Well: 316 stainless steel for 24" thermometer 3/4" NPT connection.

Instructions for Ordering: See model and specifications.

I-4 Temperature Indicator

Supplier: The Partlow Corporation
2801-03 Central Avenue
Union City, N.J.

Quantity: 1

Model: TL-335 KLP-220-15'

Price: $94

Specifications: Mercury bulb type temperature indicator.
Instrument body: Aluminum case, 5" arc type dial. Designed for wall mounting.
Thermal element: calibrated thermal element with L type plunger, 0-500°F range, 15 ft long capillary 3/4" stuffing box. All stainless steel construction.

Specifications for Ordering: See Model # and Thermal element specifications.

I-5 Temperature Indicator and Alarm

Supplier: Same as I-4

Quantity: 1

Model: M3-212KL

Price: $126

Specifications: Mercury bulb type temperature indicator and control.
Instrument body: temperature indicator equipped with normally open snap acting

Specifications: (Continued) switch. Designed for wall mounting. Thermal element: Calibrated thermal element, 0-250°F range, 15 ft long capillary, 3/4" stuffing box, 4" long bulb.

Specifications for Ordering: See Model and Specifications.

I-6 Pressure Indicator and Alarm

Supplier: Duro Gauge & Instrument Co., Inc.
449 Third Avenue
Brooklyn 15, N.Y.

Quantity: 1

Model: Alarm gage Series 190, with stainless steel gage Series 200, 0-15 psi.

Price: $75.80

Specifications: Alarm and indicating gage, with single or double circuit and high and low contacts. Closes circuit at high pressure. 115 Volts, 1/4 amp. Internal structure all 316 stainless steel. Range 0-15 psi.

Instructions for Ordering: See Model and Specifications.

I-7 Liquid Level Controller (Evaporator)

Supplier: Robertshaw-Fulton Controls Co.
New York Office: 10-32 47th Road
Long Island City 1, N.Y.

Quantity: 1

Model: Level-Tek Model 102F

Price: $200.50

Specifications: Capacitance type differential level control including teflon coated probe, armored cable,

Specifications: (Continued)

and electronically activated relay, which operates built-in signal lamps and a snap switch. Unit consists of the following:

(a) Model 102F Level-Tek with: cast aluminum case, high level fail safe, SPDT switch for control rated at 10 amps. non-inductive load 115 Volt AC, built-in red and green signal lights, 115 Volt, 60 cycle AC operation.

(b) Model # 705-A3-T18 probe assembly with: 303 S.S. gland 3/4" NPT, 303 S.S. teflon covered electrode 18" active length.

(c) Model # 714-N10 10 ft. long coaxial cable in flexible protective armor.

(d) Model # 1876 condulet.

(e) Operation instructions.

(f) Dead zone: 5" long, extending from 7" to 12" from probe connection. Electrical circuit closing at low level and opening at high level.

Instructions for Ordering: See Specifications.

I-8 Liquid Level Alarm

Supplier: Same as I-7

Quantity: 1

Model: Level-Tek Model 102-W

Price: $146.50

Specifications: Same as I-7 with the following changes:

Specifications: (Continued) Level-Tek Model 102-W

Prove length 4"

No dead zone.

Instructions for Ordering: See Model and Specifications.

I-9 Liquid Level Controller (Intermediate Condensate Tank)

Supplier: Same as I-7

Quantity: 1

Model: Level-Tek Model 102F

Price: $205.50

Specifications: Same as I-7 with the following changes: Dead zone 24" long, extending from 4" to 28" from probe connections. Electrical circuit closing at high level and opening at low level.

Instructions for Ordering: See Model and Specifications.

I-10 Steam Rotameter

Supplier: Schutte and Koerting Co.
Instruments Division
Cornwells Heights
Bucks County, Pennsylvania

Quantity: 1

Model: SK Fig. 1900-F Metal Tube Rotameter.

Price: $156

Specifications: Metal tube with flanged vertical inlet and horizontal outlet connections, stainless steel float with magnetic indication arrangement. All stainless steel construction.

Specifications: (Continued)

Overall size: 26-1/2" high, approximately 4" wide.

Capacity: up to 500 lbs./hr. of 150 psi steam.

Connections: 1" flanged.

Instructions for Ordering:

SK Fig. 1900-F Metal Tube Rotameter.

Meter size No. 6. For 150 psi steam. Flow rate up to 500 lbs./hr.

I-11 Feed Rotameter

Supplier: Same as I-10

Quantity: 1

Model: Series 18200 "Safeguard" Rotameter.

Price: $96

Specifications: Type 316 stainless steel rotor, pyrex meter tube, stainless steel fittings, welded steel case.

Overall size: 20" x 4"

Capacity: 1.46 GPM water

Pressure, max.: 350 psig.

Connections: 1/2"

Instructions for Ordering:

Series 18200 "Safeguard"

Fig. 18210

Group B

Meter size: 3-HCF

Rotor Type: 33-J

Stainless steel fittings.

I-12 Cumulative Feed Flow Meter

Supplier: Buffalo Meter Company
2917 Main Street
Buffalo 14, N.Y.

Quantity: 1

Model: BNV size chemical meter with vertical dial.

Price: $281.72

Specifications: Single piston displacement meter. Kel-F disc and ball, type 316 stainless steel internal parts and casing.
Registration: in gallons.
Flow rate: 1-12 GPM normal, 20 GPM max.
Pipe connections: 1" external threads.
Dial: vertical.

Instructions for Ordering: Liquid data: Very dilute water solution, 35-90°F., 0-50 psi. pressure, 20-60 gallons per hour.
Meter Data: Niagara Industrial Meter, BTV size chemical meter, Kel-F disc and ball, type 316 stainless steel internal parts and casing, 1" external threads, 6" vertical 1-hand meter, 10 gallon dial circle.

I-13 Condensate Sight Flow Indicator

Supplier: Eugene Ernst Products Co.
P.O. Box 427
South Main Street
Farmingdale, New Jersey

Quantity: 1

Model: Model # EEP 200-S, 1" size

Price: $99.90

I-13

Specifications: Drip tube sight flow indicator, stainless steel construction, 1" screwed end connections.

Instructions for Ordering: Model # EEP 200-S, stainless steel sight flow indicator for 1" pipe size.

I-14 Steam Pressure Regulator

Supplier: A. W. Cash Company
540 N. 18th Street
Decatur, Ill.

Quantity: 1

Model: Type D regulator, valve size 2"

Price: $90

Specifications: Pressure reducing and regulating valve with 2" screwed ends. Iron body, bronze trim stainless steel diaphragm.
Max. pressure: inlet 200 psi., outlet 125 psi.
Max. flow of steam: 492 lbs. steam per hour (150 psig. inlet pressure, 100 psig. outlet pressure).

Instructions for Ordering: Type D pressure reducing and regulating valve for steam, 2" size, iron body, bronze trim, stainless steel diaphragm.

I-15 Steam Pressure Indicator

Supplier: Same as I-6

Quantity: 1

Model: Pressure Gauge Series 100, Fig. # 101

Price: $12.50

Specifications: Bourdon type pressure gage, 4-1/2" dial, aluminum case, 0-200 psi.

Instructions for Ordering: See Model and Specifications.

I-16 Condensate Conductivity Indicator

Supplier: Industrial Instruments Inc.
89 Commerce Road
Cedar Grove, Essex County, N.J.

Quantity: 1

Model: Cell: VS01S, Bridge: RD-132

Price: $114.50

Specifications: Bridge: range 15,000 to 4 x 10^6 ohm-cm, manual temperature compensation range of 34-140°F., housed in a grey finished wall mounting metal case. Operates from 115 Volt, 50-60 cycle AC.
Cell: Epoxy molded 3/4" NPT fitting with plasticized nickel electrode. Rated at 50 psi. at 212°F. Cell constant is 0.100.

Instructions for Ordering: See Model and Specifications.

I-17 pH Recorder

Supplier: Analytical Measurements, Inc.
490 Morris Avenue
Summit, New Jersey

Quantity: 1

Model: Panel mounted analytical recording pH meter.

Price: $345

Specifications: Panel mounted analytical recording pH meter with manual temperature compensation, 115 Volts 60 cycle, complete with probe unit.

Instructions for Ordering: See Model and Specifications.

I-18 Liquid Level Gage

Supplier: Eugene Ernst Products Co.
P.O. Box 427
South Main Street
Farmingdale, New Jersey

Quantity: 2

Model: EEP 70A316

Price: $119 each; $238 total.

Specifications: Stainless steel water gage with 1/2" connections Supplied with 60" long, 5/8" O.D. Model-Clear # 500 gage glass.

P-1 Centrifugal Pump

Supplier: Bell & Gosset Co.
8200 N. Austin Avenue
Morton Grove, Ill.

New York Office: Thermafluid Dynamics, Inc.
101 Park Avenue
New York 17, N.Y.

Quantity: 1

Model: Series 1522 Uni-Built Centrifugal Pump size 3/4 AAB

Price: $445

Specifications: Stainless steel pump equipped with 115 Volt, 60 cycle, 3450 rpm single phase motor.

Pump can deliver 10 GPM and the total head is 35 ft.

Suction size: 1-1/4" NPT

Discharge size: 3/4" NPT

Instructions for Ordering: See Model and Specifications.

P-2 Centrifugal Pump

Same as P-1

SVF-1		Steam Solenoid Valve
Supplier:		Magnetrol Valve Corp. 67 Fifth Avenue Hawthorne, New Jersey
Quantity:	1	
Model:	Type No.	141SR46
Price:	$153	
Specifications:		Normally open solenoid valve. pipe size: 1-1/2", female conn. max. diff. pressure: 180 psi power: 85 watts, 115V 60 cps. material of construction: bronze max temperature: 400°F
Instructions for Ordering:		Type No. 141SR46 pipe size: 1-1/2" fluid: steam max. diff. pressure: 180 psi 115V, 60 cps

SVF-2 Feed Solenoid Valve

Supplier: The Johnson Corp.
Three Rivers, Michigan

Quantity: 1

Model: 250D3 normally closed

Price: $105

Specifications: Normally closed solenoid valve
pipe size: 3/4"
Maximum differential pressure: 150 psi
Maximum design pressure: 250 psi
Valve origice: 3/4"
Material of construction: valve seat and push rod are #303 stainless steel. The valve is #440c, and its stem #303 stainless steel.
Operated by 115V 50 cps

Instructions for Ordering: No.250D3 normally closed solenoid valve.
pipe size: 3/4"
fluid: water solution
115 V 60 cps

SVF-3 Steam Traps

Supplier: Armstrong Machine Works
Three Rivers, Michigan

Quantity: 2

Model: No.883 trap, Figure 9-2

Price: $45.50 each, $91.00 total

Specifications: Steam trap with strainer, thermal vent and check valve.

Maximum pressure: 250 psig.

pipe connections: 3/4"

Instructions for Ordering: See model and specifications

SVF-4 **Feed Filters**

Supplier: Penfield Manufacturing Co., Inc.
46 Britannia Street
Meriden, Conn.

Quantity: 2

Model: I. C. Filter

Price: $29.00 each, Refill $1.65 each, $61.30 Total

Specifications:

Cartridge type filter, with removable sump.

Made of clear polystyrene, with 325 mesh stainless steel filter.

pipe connections: 3/4"

Cartridge size: 2-3/4" x 9-3/4"

Flow rate, max.: 9 GPM

Operating pressure, max.: 100 psi

Instructions for Ordering: See model and specifications

SVF-5 Flexible Piping

Supplier: Allied Metal Hose Co.
3794 9th Street
Long Island City 1, N. Y.

Quantity: 6

Model: Allfex corrugated hoses and fittings as specified below

Price: $200.19 total

Specifications:

a. Vapor line: 3" I.D., 4" nominal O.D., 18" overall length type 321 stainless steel hose with 3" type 304 stainless steel female unions on both ends. Maximum working pressure 35 psi (SSC-0) $125.35

b. Entrained liquid return: 1" I.D., 1-5/8" nominal O.D., 14" overall length type 321 stainless steel hose with 1" type 304 stainless steel female union one end and male union on other end. 63 psi maximum working pressure (SSC-0) $26.23

c. Steam inlet (coil): 1" I.D., 1-5/8" nominal O.D., 14" overall length bronze hose with 1" brass male union on one end and female union on other end. 150 psi maximum working pressure. $11.86

d. Steam inlet (jacket): 1" I.D., 1-5/8" nominal O.D., 24" overall length bronze hose with 1" brass male union on one end and female union on other end. 15- psi maximum working pressure. $14.15

Specifications: (continued)

e. Condensate (coil): Same as (d) but 3/4" I.D., 1-1/4" nominal O.D. $11.30

f. Condensate (jacket): Same as (e)

Instructions for Ordering: See model and specifications

SVF-6 Feed Pressure Relief Valve

Supplier: Boing & Hill, Inc.
10-64 Jackson Avenue
Long Island City 1, N. Y.

Quantity: 1

Model: Farris diaphragm relief valve, Type #1010

Price: $132.20

Specifications: Diaphragm relief valve, stainless steel body and spring, Kel-F diaphragm and disc with plain cap. 8-7/8" overall height, 3/4" male inlet and 3/4" female outlet. To be set at approximately 10 psig.

Instructions for Ordering: Farris Diaphragm Relief Valve, Type #1010, plain cap, with 3/4" screwed connections.

SVF-7 Pressure Relief Valve

Supplier: Same as SVF-6

Quantity: 1

Model: Same as SVF-6

Price: $132.20

Specifications: Same as SVF-6 but set at 5 psig.

OE-1 Electrical Immersion Heater

Supplier: Power Instruments
254 Canal Street
New York 13, New York
WO 6-2140

Quantity: 1

Model: See specifications

Price: Heater $34.50, Thermostat $15.00, $49.50 total

Specifications: 304 type stainless steel 2000 watt electrical immersion heater, 25" long, 1-1/2" pipe connection (stainless steel), two heating loops. To be connected through cover of a drum where liquid level is 15" from cover. Thermostat: sensing element positioned in a well going through center of heating elements; thermostat positioned on top of the unit.

OE-2 Magnesium Electrode

Supplier: Stuart Steel Protection Corp.
P. O. Box 347
Plainfield, N. J.

Quantity: 2

Model: See specifications

Price: $25 total, Note: price depends on quantity. Same anodes can be obtained for $1.24 each in lots of 100 from the Dow Metal Products Co.

Specifications: Welded plug type anode assembly, consisting of 0.84" diameter magnesium rod with 3/4" N.P.T. plug and central steel wire welded to plug. Overall length 25"

Instructions for Ordering: See specifications

VF-1 to VF-7 Valves

Supplier: Crane Company
43-38 36th Street
Long Island City 1, N. Y.

Quantity: 35 total

Model: See below

Price: $1,535.50 total

Specifications:

VF-1 - 24; 3/4" type 316 stainless steel globe valves, model #18810, $48.75 each, $1,170.00 total.

VF-2 - 1; 3/4" type 316 stainless steel needle point valve, model #222SS $32.70

VF-3 - 2; 3/4" type 316 stainless steel check valves, model #1826, $33.80 each $67.60 total.

VF-4 - 2; 1" type 316 stainless steel globe valve model #18810, $57.20 each $114.40 total.

VF-5 - 2; 1" malleable iron globe valves with stainless steel seating surfaces and excelloy stems. Model #254P, $17.94 each $35.88 total.

VF-6 - 3, 1-1/2" same as VF-5, $28.73 each $86.19 total.

VF-7 - 1, Same as VF-5